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1912/13

Volume Five Number Two

SCHOOL OF MINES AND METALLURGY

UNIVERSITY OF MISSOURI

BULLETIN

MARCH, 1913

1912—CATALOGUE—1913

Rolla, Missouri

Entered as second-class matter January 7, 1909, at the post-office at Rolla, Missouri, under the act of July 18, 1894. Issued Quarterly.

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SCHOOL OF MINES AND METALLURGY

UNIVERSITY OF MISSOURI

FORTY-SECOND ANNUAL CATALOGUE

ROLLA, MISSOURI

1913

1913

JANUARY.

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DECEMBER.

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CALENDAR.

1913.

June 2, Monday.....Summer School Begins.

July 12, Saturday.....Summer School Closes.

September 6, Saturday.....Entrance Examinations.

September 8, Monday.....Registration for First Semester.

September 9, Tuesday.....First Semester Class Work Begins.

November 27, Thursday.....Thanksgiving Holiday.

December 19, Friday, at 4 p. m...Christmas Recess Begins.

1914.

January 5, Monday, 8 a. m.....Christmas Recess Ends.

January 23, Friday.....First Semester Ends.

January 24, Saturday.....Registration for Second Semester.

January 26, Monday.....Second Semester Class Work Begins.

May 29, Friday.....Annual Commencement.

BOARD OF CURATORS.

S. L. Baysinger.....*Rolla, Mo.*

D. R. Francis.....*St. Louis, Mo.*

A. D. Nortoni.....*St. Louis, Mo.*

J. C. Parrish.....*Vandalia, Mo.*

C. B. Rollins.....*Columbia, Mo.*

Sam Sparrow .....*Kansas City, Mo.*

T. J. Wornall.....*Liberty, Mo.*

C. E. Yeater.....*Sedalia, Mo.*

G. L. Zwick.....*St. Joseph, Mo.*

OFFICERS OF THE BOARD.

D. R. Francis.....*President.*

J. C. Parrish.....*Vice-President.*

J. G. Babb.....*Secretary.*

R. B. Price.....*Treasurer.*

EXECUTIVE COMMITTEE

OF THE

SCHOOL OF MINES AND METALLURGY.

S. L. Baysinger.....*Rolla.*

A. D. Nortoni.....*St. Louis.*

T. J. Wornall.....*Liberty.*

OFFICERS OF THE COMMITTEE.

S. L. Baysinger.....*Chairman.*

T. J. Wornall.....*Vice-Chairman.*

Edw. Kahlbaum.....*Secretary.*

C. M. Knapp.....*Treasurer.*

Director of the School,

LEWIS E. YOUNG.

Secretary of the Faculty,

JOHN B. SCOTT.

Registrar,

EDW. KAHLBAUM.

Librarian,

JESSE CUNNINGHAM.

Superintendent of Buildings and Grounds,

ROBERT R. DICKERSON.

FACULTY.

ALBERT ROSS HILL, A. B., Ph. D., LL. D.,
President of the University.
A. B., Dalhousie University, 1892; Ph. D., Cornell University, 1895; LL. D., University of South Carolina, 1905; Dalhousie University, 1908; Westminster College, 1909.

LEWIS EMANUEL YOUNG, E. M.,
Director.
B. S. in Mining Engineering, Pennsylvania State College, 1900; E. M., Iowa State College, 1904.

GEORGE REINALD DEAN, C. E.,
Professor of Mathematics.
C. E., School of Mines, 1890; B. S. in Mathematics and Physics, School of Mines, 1891.

AUSTIN LEE McRAE, S. D.,
Professor of Physics.
B. S., University of Georgia, 1881; S. D., Harvard University, 1886.

VICTOR HUGO GOTTSCHALK, M. S.,
Professor of Chemistry.
B. S. in Chemistry and Metallurgy, School of Mines, 1898; M. S., School of Mines, 1900.

ELMO GOLIGHTLY HARRIS, C. E.,
Professor of Civil Engineering.
C. E., University of Virginia, 1882.

DURWARD COPELAND, S. B.,
Professor of Metallurgy.
S. B., Massachusetts Institute of Technology, 1903.

GUY HENRY COX, B. S., M. A., Ph. D.,
Professor of Geology and Mineralogy.
B. S. in General Science, Northwestern University, 1905; M. A., University of Wisconsin, 1908; Ph. D., University of Wisconsin, 1911.

CARROLL RALPH FORBES, E. M.,
Professor of Mining.
B. S., Michigan College of Mines, 1902; E. M., Michigan College of Mines, 1903.

LEON ELLIS GARRETT, B. S.,
Associate Professor of Mathematics.
B. S. in General Science, School of Mines, 1901.

JOSEPH HENRY BOWEN,
Assistant Professor of Shop Work and Drawing.
Graduate, Miller School, Virginia.

LOUIS AGASSIZ TEST, Ph. D.,
Assistant Professor of Chemistry.
B. M. E., Purdue University, 1894; A. C., Purdue University, 1896; Ph. D., University of Chicago, 1907.

JULIUS WOOSTER EGGLESTON, B. S., A. M.,
Assistant Professor of Geology and Mineralogy.
B. S., Amherst College, 1898; A. M., Harvard University, 1901.

JOSEPH WAYNE BARLEY, A. B., A. M., Ph. D.,
Assistant Professor of English and Modern Languages.
A. B., 1897; A. M., 1905; William Jewell College; Ph. D., University of Pennsylvania, 1911.

PAUL JULIUS WILKINS, B. S.,
Instructor in Modern Languages.
B. S., Michigan Agricultural and Mechanical College, 1869.

JOHN BENNETT SCOTT, B. S.,
Instructor in English, and Secretary.
B. S. in General Science, School of Mines, 1907.

*BOYD DUDLEY, JR., B. S., M. S.,
Instructor in Metallurgy and Ore Dressing.
B. S. in General Science, School of Mines, 1908; M. S., School of Mines, 1910.

ALEXIS XAVIER ILLINSKI, B. S.,
Instructor in Metallurgy and Ore Dressing.
B. S. in Metallurgy, School of Mines, 1910.

HORACE THARP MANN, M. S., E. M.,
Instructor in Metallurgy and Ore Dressing.
B. S. in Mining Engineering, School of Mines, 1908; M. S. in General Science, School of Mines, 1909; E. M., School of Mines, 1910.

FREDERICK WILLIAM BUERSTATTE, B. S.,
Instructor in Drawing.
B. S. in Mechanical Engineering, University of Wisconsin, 1901.

*On leave of absence, session 1912-1913.

VACHEL HARRY McNUTT, B. S., M. S.,
Instructor in Mineralogy.
B. S. in Mine Engineering, 1910; M. S., 1912, School of Mines.

EDWARD HARRY McCLEARY, B. S.,
Instructor in Physical Training.
B. S. in Mine Engineering, Pennsylvania State College, 1910.

EDGAR SCOTT McCANDLISS, B. S.,
Instructor in Civil Engineering.
B. S. in Civil Engineering, Purdue University, 1909.

STUDENT ASSISTANTS.

LEONARD STEPHEN COPELIN,
Student Assistant in Chemistry.

WALTER GAMMETER,
Student Assistant in Drawing.

SCOVILL EDWARD HOLLISTER,
Student Assistant in Physics.

JOHN CHARAVELLE INGRAM,
Student Assistant in Chemistry.

FRANK LINDLEY JOHNSON,
Student Assistant in Shop Work.

MERVIN JOE KELLY,
Student Assistant in Chemistry.

ROY GOULD KNICKERBOCKER,
Student Assistant in Chemistry.

ENOCH RAY NEEDLES,
Student Assistant in Surveying.

FACULTY COMMITTEES.

Admission.

Professors Dean, Wilkins and Scott.

Athletics.

Professors Cox, Bowen, Copeland, McRae, and Test.

Buildings, Plant, and Grounds.

Professors McRae and Harris.

Degrees.

Professors McRae, Scott, and Dean.

Examinations and Schedule.

Professors Forbes, Bowen, Garrett, and Barley.

Graduate Courses.

Professors Gottschalk and Copeland.

Publications.

Professors Barley and Cox.

Student Council.

Professors Copeland, McRae, Cox, Forbes, and Mr. McCleary.

Theses.

Professors Harris, Copeland, Cox, and Forbes.

Undergraduate Courses.

Professors Dean, McRae, Cox, and Gottschalk.

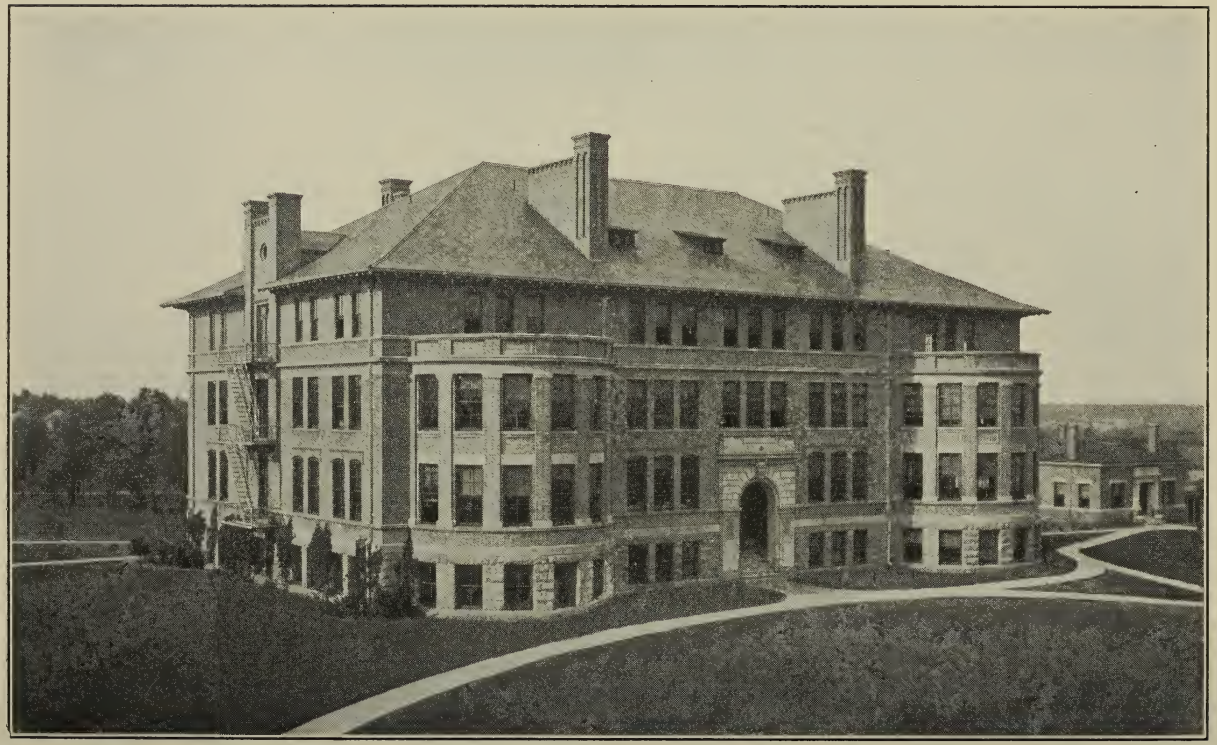
HISTORY OF THE SCHOOL.

In 1870 the General Assembly of Missouri, in accepting the donation of land for educational purposes made by the General Government through an Act of Congress, approved July 2, 1862, established an Agricultural and Mechanical College and a School of Mines and Metallurgy. The design of these institutions is set forth in the following language:

"Objects of These Colleges.—The leading objects of said colleges shall be to teach such branches as are related to agriculture and mining." (Revised Statutes, 1909, Section 11134.)

The School of Mines and Metallurgy was located at Rolla, Phelps County. Here, in November, 1871, the school was formally opened. The statutes fix the status of the school as one of the Colleges of the State University. Its affairs are under the immediate supervision of an Executive Committee, consisting of three members of the University Board of Curators, selected by that body. The need of general culture as a foundation and accompaniment of specifically technical training led to the establishment, in 1885, of an Academic Course in compliance with the following Act of the General Assembly:

"Academic Course of Study, Etc.—That the obligation of the State to the General Government, assumed by the acceptance of the land grant of July 2d, 1862, may be more fully discharged, and in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life, the Board of Curators of the University of the State of Missouri shall prescribe and adopt a liberal academic course of study to be taught in the School of Mines and Metallurgy located at Rolla, in addition to the courses now taught in said school, and may confer the degree of bachelor of science upon all students who shall complete said course in said school to the satisfaction of the faculty thereof." (Revised Statutes, 1909, Section 11135.)



NORWOOD HALL

FINANCES.

The proceeds from the sale of the public lands granted by the General Government amount to about $350,000, which is invested in State certificates of indebtedness bearing 5 per cent interest. The School of Mines receives one-fourth of the yearly income thus accruing.

By an Act of Congress, approved August 30, 1890, commonly known as the "Morrill Bill," the General Government assists each State and Territory in maintaining a college or colleges in accordance with the act of July 2, 1862. After deducting one-sixteenth for the Lincoln Institute, Missouri gives one-fourth of the remainder of this fund to the School of Mines.

In 1891 the Government returned to the various States the sums collected from their citizens by the imposition during the Civil War of a "direct tax." The amount thus refunded to Missouri was $646,958.23, and the Thirty-sixth General Assembly of the State won the gratitude of the friends of higher education by establishing this as a permanent endowment for the State University at Columbia and the School of Mines and Metallurgy at Rolla. One-fifth of the income from this endowment is received by the School of Mines.

The Fortieth General Assembly of the State passed an act providing for a tax on collateral inheritances for the benefit of the State University, and the Forty-first General Assembly provided that one-fifth of the funds derived from this tax shall be appropriated for the benefit of the School of Mines.

ENDOWMENT.

The State endowment of the School of Mines is set forth in the following extracts from the Statutes of Missouri:

"The proceeds of the sale of lands donated to the State of Missouri by the United States for the support of the College of Agriculture and Mechanic Arts and the School of Mines and Metallurgy, by Act of Congress, approved July 2, 1862, represented by State certificates of indebtedness, of the following amounts and dates:

July 2, 1883	$242,000.00
November 1, 1883	5,000.00
January 29, 1884	5,000.00
April 19, 1884	35,000.00
April 2, 1885	5,000.00
February 25, 1886	5,000.00
January 1, 1888	5,000.00
December 15, 1888	5,000.00
May 15, 1889	5,000.00
July 1, 1891	5,000.00
May 15, 1893	5,000.00
July 1, 1895	22,881.19
April 9, 1895	5,000.00
Representing a total of	$349,881.19

Now issued or any certificates which may hereafter be issued under any general or special act of the General Assembly; one-fourth of the interest of these funds shall be paid to the Treasurer of the School of Mines and Metallurgy, at Rolla, for the maintenance of said institution."

"The proceeds of sales of lands donated to the School of Mines and Metallurgy, at Rolla, represented by the State certificate of indebtedness of $2,000, dated April 15, 1893, issued under act March 31, 1883, interest on which shall be applied to the maintenance of the School of Mines and Metallurgy, at Rolla."

"The State certificate of indebtedness of $3,000, issued under act of April 1, 1895, dated April 1, 1896, four-fifths of the interest to be applied to the maintenance of the State University, at Colum-

bia, and one-fifth to the School of Mines and Metallurgy, at Rolla, and also any other certificates which may hereafter be issued and held in trust for this fund under any general or special act of the General Assembly." (Revised Statutes, 1909, Section 11161.)

"The State certificate of indebtedness of $646,958.23, derived from 'direct tax' received from the United States, dated April 1, 1891, issued under act of March 26, 1891, four-fifths of the interest to be applied for the maintenance of the State University, at Columbia, and one-fifth for the School of Mines and Metallurgy, at Rolla." (Revised Statutes, 1909, Section 11161.)

"All sums collected under the provisions of an Act of Congress, approved August 30, 1890, commonly known as the 'Morrill Bill,' shall be paid as follows: One-sixteenth thereof for the benefit of the Lincoln Institute and one-fourth of the remainder to the Treasurer of the School of Mines, at Rolla, Missouri." (Revised Statutes, 1909, Section 11171.)

Collateral Inheritance Tax.—"The moneys received by the State Treasurer under the provisions of this article shall be deposited in the State Treasury to the credit of the fund now existing in the State Treasury, and known as the 'State Seminary Moneys,' for the maintenance, support and better equipment of the buildings, apparatus, books, instruction, etc., of the University of the State of Missouri, to an amount not exceeding in any one year the equivalent of one-tenth of one mill for every dollar of the assessed valuation of taxable property of the State for the said year; *Provided*, that one-fifth of all such moneys so received shall be devoted to the use of the School of Mines and Metallurgy, a department of the said University." (Revised Statutes, 1909, Section 312.)

LOCATION.

The School of Mines is located at Rolla, the county seat of Phelps County, on the St. Louis and San Francisco Railroad, approximately halfway between St. Louis and Springfield.

Rolla is on the crest of the Ozark uplift, at an elevation of eleven hundred forty feet above the sea level, and has an agreeable and notably healthful climate. Its position on a great transcontinental railway system makes it readily accessible.

The school is within easy reach of the important mining districts of the State, which offer splendid facilities for the study of mining geology, mining methods, ore dressing, and mining machinery. Numerous recent improvements, due to the systematic study of Missouri ore deposits, methods of ore treatment, and the extensive development of low-grade lead and zinc ores, have given the school advantages for the application of the theories of geology, mining, and ore dressing to practice.

The smelting industry of the State is very important and every courtesy is extended to the professors and students of the school during their visits to these metallurgical plants. The methods of mining coal and clay can be readily studied in Missouri and the adjoining fields. Numerous clay-working and cement plants in St. Louis and the vicinity offer good opportunity for the study of these important industries. In and about St. Louis are also various chemical plants which are visited from time to time.

CAMPUS AND ATHLETIC FIELD.

The grounds of the School of Mines are situated in the highest part of the City of Rolla, and are over twenty-seven acres in extent. The campus contains beautiful lawns, groves of native oak, and many shade trees.

The Jackling Field has a good baseball diamond, a football gridiron, tennis courts, and a 440-yard running track. On the athletic field there is a suitable building providing shower baths and a dressing room for the various athletic teams.

ROLLA BUILDING

BUILDINGS.

Rolla Building.

This building was originally built by the City of Rolla as a High School building, but was sold to the State in 1871, and for many years was the principal building of the School of Mines and Metallurgy. It is a brick structure, ninety feet by sixty feet, four stories high, including a working basement. It contains the library, laboratories, drafting rooms, offices, and geological collections of the State Geological Survey, recitation rooms for mathematics and modern languages, toilet, shower baths, and locker rooms.

Chemical Hall.

The main portion of this building was erected in 1885 and two wings were added in 1902. The main building is two stories high and one hundred two feet in length by fifty-five feet in width. Each wing is fifty-five feet by sixty feet and one story high. This entire building, including a large basement, is used for chemistry.

Mining Building and Power Plant.

This building, erected in 1895, is a tile-roof, press-brick structure, and consists of two distinct portions, one containing offices, an instrument room, and laboratories—the other comprising a large mining laboratory, an engine room, and a boiler room.

Mechanical Hall.

This two-story brick building, erected in 1901, is one hundred fifty feet by sixty feet and was specially designed for mechanical work. The second floor includes a demonstration lecture room, a shop for bench-work in wood, and a temporary gymnasium. The first floor contains a lathe room for wood-turning, a forge room, a metal-working room, and a stock and tool room.

Each floor is provided with a lavatory and lockers, and an office for the instructor.

Norwood Hall.

The corner stone of this building was laid November 23, 1902, and the building was first used in 1903. It contains adequate quar-

ters for lecture and recitation rooms for physics, geology, mineralogy, civil engineering, English, mathematics; also drawing rooms and laboratories for physics, geology, mineralogy, and civil engineering.

Ore Dressing Building.

This is a three-story gray press-brick building with a basement and two large one-story wings. Two stories and the west wing have been in use since January, 1908, and the east wing was erected in 1909. The building provides quarters for metallurgy and ore dressing. The building was completed in 1911 and contains over twenty-five thousand square feet of floor space.

Parker Hall.

This is a fire-proof, two-story gray press-brick building, with a well-lighted basement. The main portion of the building is one hundred two by fifty-five feet and the wing is fifty-eight by sixty feet. The library will occupy the second story of the building; the administrative offices, faculty room, and board room will be located on the first floor; and the assembly room will be in the two-story wing. This building was erected in 1912.

Gymnasium Building.

The Forty-Seventh General Assembly appropriated Seventy Thousand Dollars for erecting and equipping a fire-proof gymnasium. This will be modern in design and will be equipped for systematic physical training and for indoor athletic contests. It will contain a swimming-pool and a running-track.

Director's Residence.

This is a two-story brick and frame building, erected in 1889 and used for a number of years as a student club-house and dormitory.

Athletic Building.

A one-story frame building, thirty-seven by thirty-four feet, formerly used as a wood shop, is now used by the athletic teams and provides dressing rooms, lavatory, and store room for athletic supplies.

Carpenter Shop.

The general repair work of the School and construction of laboratory equipment is carried on in a frame building, one hundred fifty feet by twenty-two feet. This building is located west of Mechanical Hall, and includes a store room for lumber.

LIBRARY.

The Library, which is now occupying limited quarters in Norwood Hall, will be moved into its new rooms in Parker Hall within a few months, and will be completely organized and ready for service there before the opening of the fall semester. The new quarters consist of a large, well-lighted reading room, a stack room equipped with a double-deck Snead stack, capacity forty-five thousand volumes, and adequate work rooms for the Library staff. All equipment is to be new and up-to-date, meeting in every way the needs of the Library and its clientele.

The collection of books now numbers fourteen thousand five hundred carefully selected volumes, together with a large collection of pamphlets, bulletins and reports of mining companies. The bulk of the collection consists of works in the Sciences, chiefly Geology, Physics and Chemistry, and the Useful Arts, the main part of this division being Engineering and Mining treatises. Besides these collections, the Library has the representative works in American and English Literature, some fiction, a good section of Biography and the latest books of description and travel, this latter division being kept especially strong so that the students may keep informed concerning the manners and customs of the people and the characteristics of the countries into which they are likely to go to follow their vocation.

The Library is a subscriber to the leading technical periodicals and the publications and transactions of societies and congresses. The leading general magazines are taken for recreational reading. The contents of the back files of this material is made available through the general periodical indexes and the engineering and mining indexes. A full dictionary catalogue of authors, titles and subjects is being made by the Library.

The reading room is open ten hours daily, except Saturday, when it is open five hours. On Sunday the Library is open from 2 P. M. to 4 P. M. Books and periodicals may be borrowed by all officers and students of the school, and by others having special permission.

The Library is a designated depository for all congressional documents.

ADMISSION.

Under the statutes persons of either sex, sixteen years of age or over, whether residents of Missouri or not, may be admitted upon evidence of sufficient preparation. Students should have a good liberal education, its elements at least, before beginning technical study. The average age of members of the present Freshman class at entrance was about eighteen years. Specific requirements have been fixed by consideration of the express design of the school—"to promote the education of the industrial classes" in certain branches of engineering—and for the educational opportunities of its intended beneficiaries. The requirements for admission to the Freshman class are as follows:

The applicant must file with the Director a satisfactory certificate of good moral standing.

Admission by Examination.—Applicants for admission, not having diplomas from approved schools, are required to pass examinations in fifteen units, a unit being the equivalent of a year's work in one subject, as given in an approved high school.

Of these fifteen units the following are required: Three units in English, one and one-half units in Algebra, one unit in Plane Geometry, and one-half unit in Solid Geometry. The remaining nine units may be selected from the following list:

Subject.	Maximum.	Minimum.
English	4	3
Algebra	1½	1½
Plane Geometry	1	1
Solid Geometry	½	½
Trigonometry	1	½
History	4	1
Civil Government	½	½
Latin	4	2
Greek	3	2
German	3	2
French	3	2
Spanish	3	2
Physics	2	1
Chemistry	2	1
General Biology	2	1

Subject.	Maximum.	Minimum.
Zoology	2	1
Botany	2	1
†Physiology	1	1
Physical Geography	1	1
Drawing	2	1
*Manual Training	2	1
*Economics	½	½
*Commercial Geography	½	½
*Bookkeeping	1	1

MATHEMATICS. (4 UNITS.)

The four units which may be offered in mathematics are as follows:

ALGEBRA. (1½ Units.) Elementary algebra, including the elementary operations, solution of simple and simultaneous linear equations, factoring, radicals, exponents, quadratic equations, equations containing radicals, imaginaries, simultaneous quadratics, higher equations solved as quadratics, relations of roots and coefficients of quadratics and higher numerical equations, solution of higher equations by factoring, Horner's method of approximation, binominal theorem for positive integral exponent, ratio and proportion, and logarithms.

While the study of these particular subjects is recommended, it is not expected that the student shall be able to pass an examination on each and every one of them. He must produce evidence, however, of having studied algebra for one and one-half years under a good teacher in an accredited high school.

PLANE GEOMETRY. (1 Unit.) The work in Plane Geometry must cover a full year in any good text. It is recommended that considerable attention be paid to the applications of the algebra to geometry, and of geometry to algebra and arithmetic.

SOLID GEOMETRY. (½ Unit.) A full half-year's work is required in Solid Geometry. The same recommendations apply here as in Plane Geometry, with the additional requirement that the student be drilled in arithmetical work in computing areas and volumes.

TRIGONOMETRY. (1 Unit.) It is to be understood at the outset that this work will not be accepted for advanced standing. This branch of mathematics is of such great importance to the practical

†In cases where the study of Physiology has been preceded by a year's study of Biology.

*The maximum amount of commercial and industrial subjects accepted is four units.

engineer that the whole subject must be reviewed, and the student led to a point of view which it is impossible to attain in a high school course.

ENGLISH. (4 UNITS.)

The four units that may be offered in English include grammar, composition and rhetoric, and literature.

The candidate will be required to show a reasonable proficiency in the principles of English grammar, including sentence-analysis. He will be required to show the ability to express himself coherently and correctly, with a fair mastery of the forms of writing, spelling and punctuation, sentence and paragraph structure. He will be examined on the literature listed below, and, if he desires four units, will be required to show also a knowledge of the history of English literature.

The classics prescribed are as follows:

I. For Study and Practice. Shakespeare's *Macbeth;* Milton's *Lycidas, Comus, L'Allegro* and *Il Penseroso;* Burke's *Speech on Conciliation* or Washington's *Farewell Address,* and Webster's *First Bunker Hill Oration;* Macaulay's *Life of Johnson* or Carlyle's *Essay on Burns.*

II. For Reading. Group 1 (two to be selected): Shakespeare's *As You Like It; Henry V.; Julius Caesar; The Merchant of Venice; Twelfth Night.*

Group 2 (one to be selected): Bacon's *Essays;* Bunyan's *The Pilgrim's Progress,* Part I.; Addison's *Sir Roger de Coverley;* Franklin's *Autobiography.*

Group 3 (one to be selected): Chaucer's *Prologue;* Spenser's *Faerie Queene* (Selections); Pope's *The Rape of the Lock;* Goldsmith's *The Deserted Village;* Palgrave's *Golden Treasury* (First Series), Books II. and III., with especial attention to Dryden, Collins, Gray, Cowper, and Burns.

Group 4 (two to be selected): Goldsmith's *The Vicar of Wakefield;* Scott's *Ivanhoe;* Scott's *Quentin Durward;* Hawthorne's *House of the Seven Gables;* Thackeray's *Henry Esmond;* Mrs. Gaskell's *Cranford;* Dickens' *A Tale of Two Cities;* George Eliot's *Silas Marner;* Blackmore's *Lorna Doone.*

Group 5 (two to be selected): Irving's *Sketch Book* (Selections); Lamb's *Essays of Elia;* DeQuincey's *Joan of Arc* and *The English Mail Coach;* Carlyle's *Heroes and Hero Worship;* Emerson's *Essays* (Selected); Ruskin's *Sesame and Lilies.*

Group 6 (two to be selected): Coleridge's *The Ancient Mariner;* Scott's *The Lady of the Lake;* Byron's *Mazeppa* and *The Prisoner of Chillon;* Palgrave's *Golden Treasury* (First Series), Book IV., with

especial attention to Wordsworth, Keats, and Shelley; Macaulay's *Lays of Ancient Rome;* Poe's *Poems;* Lowell's *The Vision of Sir Launfal;* Arnold's *Sohrab and Rastum;* Longfellow's *The Courtship of Miles Standish;* Tennyson's *Lancelot and Elaine, The Passing of Arthur, Gareth and Lynette;* Browning's *Cavalier Tunes, The Lost Leader, How They Brought the Good News from Ghent to Aix, Evelyn Hope, Home Thoughts from Abroad, Home Thoughts from the Sea, Incident of the French Camp, The Boy and the Angel, One Word More, Herve Riel, Pheidippides.*

HISTORY.

Four units may be offered in history; one each in Ancient History, Medieval and Modern History, English History, and American History.

Civil Government. One-half unit may be offered in Civil Government. This is the equivalent of one-half year's work in the fourth year of a high school and the applicant should have a knowledge of the chief organs of local, state, and national government, and a knowledge of the historical development of the government.

PHYSIOGRAPHY.

A student may offer one unit in physiography. A description of this unit will be sent on request.

PHYSICS.

The two units that may be offered in physics are as follows:

1. A year's work, five periods per week, of which at least two must be double periods in individual laboratory work. At least thirty-five exercises, selected from a list of sixty or more, equivalent to those recommended by the National Educational Association, must be completed.

2. A continuation of the laboratory for another year, or a year's work in a more advanced text together with the laboratory work.

Laboratory note-books must be presented by those who are required to take the entrance examination.

DRAWING.

Two units may be offered.

The following outline recently adopted by the North Central Association of Colleges and Secondary Schools, indicates the nature of the work which should be included in the two units of drawing. While the work is not separated here, into a first and second year program, the more elementary forms of each phase of the subject should be selected for the first year.

a. Pictorial. Plant study (flowers, sprays of leaves, seed, pods, etc.). Object study (elementary perspective). Landscape (roof studies, buildings, etc., elementary perspective). Pose drawing.

b. Decorative Composition. Plant forms, object study, landscape pose.

c. Decorative Design. Plant analysis (for the purpose of design). Decorative units, borders, surfaces, corners, rosettes, posters, book-covers, etc. Arrangement of straight lines, and of straight and curved lines. Geometric design. Lettering (printing).

d. Constructive Design. Designs for pottery, leather, cardboard, construction, etc.

e. Crafts. Pottery, leather (choice of one).

f. Applied Design. Design applied to cardboard, textiles, etc.

g. Instrumental Drawing such as is needed to meet the requirements of practical designing and construction.

The candidate should have some knowledge of the history of the industry and art, and some knowledge of civic planning, domestic architecture and decoration.

NOTE.—Mediums used are pencil, charcoal, water color, crayons, brush and ink, and a combination of the pure mediums.

MANUAL TRAINING.

Two units in manual training may be offered. One unit should be in Bench Work and one in Mechanical Drawing. The time required in each of these subjects is five double periods for one year or five single periods for two years. Where conditions permit it is generally advisable to give these subjects as parallel courses.

LATIN.

The four units that may be offered in Latin are as follows:

1. Collar and Daniell's First Latin Book, or the equivalent.

2. Three books of Caesar's Gallic War with composition based thereon in Moulton and Collar's Preparatory Latin Composition or in Daniell's New Latin Composition. For one book of the Gallic War the equivalent in time of Viri Romae, Nepos, or Eutropius may be offered.

3. Two additional books of the Gallic War and four Orations of Cicero with compositions based thereon in the books mentioned above.

4. Ovid's Metamorphoses (2,000 lines) and four books of Virgil's Aeneid, with prosody.

GREEK.

The three units that may be offered in Greek are as follows:

1. Ball's Elements of Greek, or White's First Greek Book.

2. Four books of Xenophon's Anabasis, Pearson's Greek Prose Composition, or its equivalent, Goodwin's Greek Grammar.

3. Ten Orations of Lysias and the first four books of Homer's Odyssey, or an equivalent amount of other Greek authors. Bridgman's Parallel Exercises based on Lysias.

GERMAN, FRENCH, SPANISH.

Three units may be offered in German, French, or Spanish. A description of the units will be sent on request.

CHEMISTRY.

The two units that may be offered in chemistry are as follows:

1. A year's work in chemistry, five periods per week, of which at least two must comprise laboratory work.

2. A second year's work in the subject, five periods per week, of which at least two must be laboratory work.

Note-books showing work done must be presented by those who are required to take the entrance examinations.

These courses will be accepted for admission, but not for advanced standing.

BOOKKEEPING.

One unit may be offered.

The student should become familiar with the meaning of double entry terms, with rules for debit and credit, and the kinds and uses of books. He should acquire the ability to keep a double entry and a single entry set of books. Furthermore, he should become familiar with such standard business forms as bills, receipts, checks, notes, time and sight drafts, endorsements, invoices, accounts, sales, deposit tickets, express receipts, bills of lading, statements of account, balance sheets, etc. He should become familiar also with the forms of business letters, beginnings and endings, etc., and should know how to write and answer telegrams and advertisements.

Bookkeeping should be done largely under the eye of the teacher as laboratory work. Good penmanship, neatness in work, accuracy and speed must be acquired in such laboratory practice. The exercises in some of the texts which are offered by the various publishers on first lessons or elementary principles would naturally form the basis for much of such work, unless the teacher prepares

his own exercise work according to a similar plan. The best evidence of good work in this subject is the character of exercise work which the student can present as a result of his laboratory practice.

Some of the best reference works, useful especially to the teacher in charge of elementary work, are Sprague's *Philosophy of Accounts*, Hatfield's *Modern Accounting*, Lisle's *Accounting in Theory and Practice*, Dicksee's *Bookkeeping for Accounting Students*, and Cole's *Accounts—Their Construction and Interpretation.*

COMMERCIAL GEOGRAPHY.

One-half unit may be offered.

The object of this course is to discover the causes of the present territorial distribution of industries and of the location of lines of communication and transportation. It should treat in detail with reference to the United States, and in less detail with reference to the outlying possessions of the United States and to the most important commercial countries, the following topics: (1) the effect of surface, soil, climate, etc., that is, the physical factor in commerce; (2) the influence of race, religion, education, commercial policies, etc.; that is, the human factor in commerce; (3) the effect of economic forces on production and commerce; (4) means of transportation and communication. The text-book should be supplemented by map work and assigned readings. The census of manufactures in the United States and other countries would form a valuable reference library, both for the purpose of map work and assigned readings.

It is desirable that for purposes of illustration, samples of commercial staples, lantern slides, stereopticon pictures, etc., should be freely employed; and wherever possible, that visits of inspection be made and informal lectures secured by experts in various industries. Commercial Geography should be preceded by Physical Geography, in case both are given.

Admission on Diploma.—Applicants may be admitted upon certificate from a college, high school, or preparatory school when the Faculty is satisfied that the work certified to covers the requirements of the School of Mines and Metallurgy.

Each applicant must file with his diploma a statement, on a School of Mines and Metallurgy blank, from his superintendent or principal, showing that the applicant has to his credit fifteen units.

Following is a list of schools whose courses have been approved by the University, and whose diplomas will admit to the Freshman class without examination.

ACCREDITED SCHOOLS.

Albany High School
Alton (Ill.) High School
Appleton City Academy
Armstrong High School
Aurora High School
Bartlesville (Okla.) High School
Belton High School
Bethany High School
Blees Military Academy, Macon
Bloomfield High School
Bolivar High School
Bonne Terre High School
Boonville High School
Bowling Green High School
Braymer High School
Breckenridge High School
Brookfield High School
Brunswick High School
Butler High School
Cainsville High School
Cairo (Ill.) High School
California High School
Cameron High School
Campbell High School
Canton High School
Cape Girardeau High School
Carleton College
Carrollton High School
Carterville High School
Carthage High School
Caruthersville High School
Centralia High School
Charleston High School
Chillicothe High School
Christian College
Clayton High School
Clinton High School
Cottey College (Nev.)
Covington (Ind.) High School
Culver (Ind.) Military Academy
Davenport (Ia.) High School
De Soto High School
Dexter High School
Doniphan High School
East St. Louis (Ill.) High School
Eldon High School
Elmwood Seminary
Enid (Okla.) High School
Excelsior Springs High School
Farmington High School
Ferguson High School
Flat River High School
Fort Scott (Kan.) High School
Fort Smith (Ark.) High School
Fredericktown High School
Fulton High School
Gallatin High School
Grant City High School
Greenfield High School
Guthrie (Okla.) High School
Hamilton High School
Hannibal High School
Hardin High School
Harrisonville High School
Higginsville High School
Holden High School
Hopkins High School
Hot Springs (Ark.) High School
Huntsville High School
Iberia Academy
Independence High School
Jackson High School
Jackson Military Academy
Jefferson City High School
Joplin High School
Kansas City Central High School
Kansas City Manual Training High School
Kemper Military Academy, Boonville
Kennett High School
Keokuk (Ia.) High School

Kewanee (Ill.) High School
Keytesville High School
Kidder Institute
Kirksville High School
Kirkwood High School
Knobnoster High School
Lamar High School
Lancaster High School
La Plata High School
Leavenworth (Kan.) High School
Lee's Summit High School
Lexington High School
Linneus High School
Little Rock (Ark.) High School
Lockwood High School
Logan County High School (Guthrie, Okla.)
McAlester (Okla.) High School
Macon High School
Maitland High School
Malden High School
Maplewood High School
Marionville Collegiate Institute
Marshall High School
Maryville High School
Memphis High School
Mexico High School
Miami (Okla.) High School
Milan High School
Missouri Wesleyan College
Moberly High School
Monett High School
Monroe City High School
Montgomery City High School
Mound City High School
Mt. Vernon High School
Muskogee (Okla.) High School
Neosho High School
Nevada High School
New London High School
New Madrid High School
Norborne High School
Odessa High School
Oklahoma City (Okla.) High School
Okmulgee (Okla.) High School
Oregon High School
Palmyra High School
Paola (Kan.) High School
Paris High School
Pawnee (Okla.) High School
Pierce City High School
Pine Bluff (Ark.) High School
Plattsburg High School
Pleasant Hill High School
Poplar Bluff High School
Princeton High School
Quincy (Ill.) High School
Richmond High School
Ridgeway High School
Rolla High School
St. Charles High School
St. Charles Military Academy
St. Joseph Central High School
St. Louis Central High School
St. Louis McKinley High School
St. Louis Manual Training School
St. Louis Yeatman High School
St. Paul's College
Salisbury High School
Savannah High School
Sedalia High School
Shelbina High School
Shelbyville High School
Shreveport (La.) High School
Sikeston High School
Smith Academy
Springfield High School
Stanberry High School
Synodical College, Fulton
Tipton High School
Trenton High School
Troy High School
Tulsa (Okla.) High School
Unionville High School
University High School
University Military School (Mobile, Ala.)
University Preparatory School (Tonkawa, Okla.)
Van Buren (Ark.) High School
Vandalia High School
Vinita (Okla.) High School
Walther College, St. Louis

Warrensburg High School
Washington High School
Webb City High School
Webster Groves High School
Wellston Station High School, St. Louis
Wellsville High School
West Plains High School
Western Military Academy
Westport High School
Windsor High School

Advanced Standing.—Candidates may be admitted to advanced standing either upon examination in the subjects of the previous year or years, or upon certificate from another institution of work accomplished, which is, in the estimation of the Faculty, equivalent to that completed here by the class into which entrance is sought. Applicants for advanced standing should communicate with the Director as early as possible, and all claims for advanced standing, in order to receive recognition, must be made by the student within one term after entrance.

Special Students.—Special students may be admitted without passing the regular examinations required for entrance, under the following conditions: 1. They must be at least twenty-one years of age. 2. They must show good reasons for not taking a regular course. 3. They must pass such examinations or other tests as shall demonstrate fitness to pursue profitably all the subjects selected by them. 4. They shall not be candidates for a degree. 5. Special students are expected to do particularly good work in the subjects which they choose. If, at any period of the session, their work becomes unsatisfactory, their connection with the school will be severed. When the work is chiefly of a laboratory nature they will be required to take at the same time as much class-room work as the Faculty may designate for each particular case.

Since there are many persons who would profit by the opportunities for education offered at the school, but who are unable, through lack of time or preliminary training, to undertake the work of the regular course, the Faculty has made the above provision. In this way it hopes to broaden the usefulness of the school, and to enable it to fulfill its purpose in as liberal a manner as possible.

CURRICULA.

It is the object of the instruction at this institution, first, to lay a broad and solid foundation by acquaintance with principles and theory, and to supplement this, wherever possible, by the discipline of practical application in the laboratory and field. Lectures and recitations are arranged for the morning hours, leaving the afternoon for laboratory and field work. The practical work is designed to illustrate and impress principles, to familiarize the student with the use of instruments with which he is to be concerned in the work of his profession, and to afford an opportunity for original investigation. What is taught orally in the lecture room is applied and illustrated in the laboratory.

The courses are the same in the Freshman year and differ but slightly in the Sophomore year. The student has thus an opportunity to defer his choice of a specialty until he has spent some time in technical study, and can better estimate his inclinations and capacities.

One hour is given to each recitation or lecture period. The afternoon periods are given to drawing, laboratory and field work, and are of three hours' duration; one laboratory period of three hours is rated as equivalent to one and one-half credits.

The School of Mines and Metallurgy offers four undergraduate curricula and three graduate curricula, as follows:

I. Mine engineering, leading to the degree of Bachelor of Science in Mine Engineering. This is a general course in Mine Engineering, having in view all the operations in connection with mining from the prospecting to the delivery of the finished product on the market.

The entire Senior year is elective and the schedule of hours is so arranged that electives may be chosen to make up groups of studies as follows: Metal Mining; Coal Mining; Mining Geology; Mining, Metallurgy, and Ore Dressing; Mining Machinery; and Mining—Civil Engineering.

II. Metallurgy, leading to the degree of Bachelor of Science in Metallurgy. This curriculum contemplates especially processes in Metallurgy subsequent to the delivery of ore above ground. It fits

a man for positions in connection with concentrating plants and smelters and various branches of industrial chemistry.

III. Civil Engineering, leading to the degree of Bachelor of Science in Civil Engineering. This is a curriculum in engineering as applied especially to railways, highways, and municipal works.

IV. General Science, leading to the degree of Bachelor of Science in General Science. This curriculum is largely elective and provides for a liberal education in science.

V. Graduate Curriculum in Mine Engineering, leading to the degree of Engineer of Mines. The curriculum is open to Bachelors of Science in Mine Engineering.

VI. Graduate Curriculum in Metallurgy, leading to the degree of Metallurgical Engineer. This curriculum is open to Bachelors of Science in Metallurgy.

VII. Graduate Curriculum for Engineers, leading to the degree of Engineer of Mines. This curriculum is open to Bachelors of Science in Civil, Electrical, or Mechanical Engineering.

The school reserves the right to omit for any semester any subject for which at least three students do not register.

GRADUATE COURSES.

The School of Mines offers graduate work in Mining Engineering, Metallurgy, Ore Dressing, Geology, Economic Geology, Petrography, and Advanced Chemistry. The attention of graduates of engineering schools and of mining schools is directed to the following courses:

Mine Management
Mining Machinery
Mining Machinery Laboratory
Mining Law
Mine Examination and Reports
Mine Plant
Mine Plant Design
Mine Power Plant
Mining Economics
Economic Geology
Geology of the United States
Structural and Metamorphic Geology
Petrography
Petrography Laboratory
Cement and Concrete Structures
Compressed Air
Compressed Air Laboratory
Engineering Designs
Ore Dressing Laboratory
Ore Dressing Problems
Ore Supply
Metallurgy Organization
Metallography
Constitution of Alloys
Metallurgical Problems
Metallurgical Plant
Metallurgical Plant Design
Cyaniding
Electro-Metallurgy
Electro-Metallurgy Laboratory
Metallurgical Research
Electro-Chemistry
Water Analysis
Physical Chemistry
Theoretical Chemistry
Advanced Physico-Chemical Laboratory
Internal Combustion Engines

Graduates from the four-year curriculum in Mining Engineering may pursue graduate work leading to the degree of Engineer of Mines. Electives may be chosen along any line approved by the Faculty.

A similar graduate curriculum is offered in Metallurgy. This leads to the degree of Metallurgical Engineer.

Graduates in Civil, Electrical, and Mechanical Engineering, who desire to specialize in Mining, may secure the degree of Engineer of Mines by complying with V. on page 34. Considerable latitude will be granted men who are qualified to undertake research work.

ASSAY LABORATORY

SPECIAL COURSES.

In addition to the seven regular curricula leading to degrees, before mentioned, a number of shorter courses are also offered. They are: *Chemistry and Assaying, Mining, Surveying, and Electricity.* They have been planned for the benefit of those who for various legitimate reasons, are unable to take the regular four-year courses.

The course in *Assaying and Chemistry* requires two years' work, although mature students, who have already some knowledge of chemistry, may complete it in one year.

The purpose of the course in *Surveying* is to develop competent land and mining surveyors and fair draftsmen. The essentials of it are a thorough knowledge of algebra, trigonometry, surveying, field practice, and drawing. One school year and the first term of a second year will be required for the completion of this course.

A short course in *Mining* is offered to students, especially such as have had some practical experience, who may wish to fit themselves for holding important positions about mines or in ore-dressing plants, but who are unable, on account of the lack of preparation or of time, to take the full course in Mining Engineering. Besides mathematics this course includes general chemistry, assaying, mineralogy, geology, mining, surveying, and English.

A course in *Electricity* is offered to furnish the student with the theory of electricity, and acquaint him with its application in the arts. This subject is of great importance to every engineer, especially to the mining engineer, since electricity has become such an important factor in mining operations.

DEGREES.

I. The degree of Bachelor of Science in Mine Engineering will be conferred upon a candidate for a degree who has completed the prescribed work of the first three years of Curriculum I., fifty-six units elective work including a thesis, and all of the required trips of Curriculum I. The final year's work must be done in residence.

II. The degree of Bachelor of Science in Metallurgy will be conferred upon a candidate for a degree who has completed the prescribed work of the first three years of Curriculum II., fifty-six units elective work including a thesis, and all of the trips required in Curriculum II. The final year's work must be done in residence.

III. The degree of Bachelor of Science in Civil Engineering will be conferred upon a candidate for a degree who has completed the required subjects and the prescribed number of electives of Curriculum III., and a satisfactory thesis. The final year's work must be done in residence.

IV. The degree of Bachelor of Science in General Science will be conferred upon a candidate who has completed the prescribed subjects and electives of Curriculum IV., and a satisfactory thesis. Candidates for degrees in General Science must matriculate in the General Science Curriculum not later than the beginning of the Junior year. The final year's work must be done in residence.

V. The degree of Engineer of Mines, Metallurgical Engineer, or Civil Engineer will be conferred upon a candidate who holds the degree of Bachelor of Science in Mine Engineering, Bachelor of Science in Metallurgy, or Bachelor of Science in Civil Engineering respectively, and who has completed in residence fifty-three units and a satisfactory thesis; or upon a graduate in Curriculum I., II., or III., respectively, who has had professional experience in a responsible position for not less than three years. A satisfactory thesis recording the result of some original investigation or independent research in a subject connected with his work, accompanied by such drawings as may be necessary to illustrate it, is required of each candidate for an advanced degree.

A candidate for a professional degree is required to submit a list of companies for whom he has worked, with the positions held, the kind of work done, and the length of service.

When a candidate's professional work has been along another line than that in which he received his college training, he may receive the professional degree in that line after five years of practice and by complying with the foregoing statement concerning detailed report of employment and thesis.

Only one professional degree will be allowed for work done *in absentia.*

VI. The degree of Master of Science will be conferred only upon graduates in General Science who have completed a year's graduate work in residence and demonstrated ability by research work and a thesis. Each candidate who is not a graduate of this institution in Curriculum IV. must satisfy the language requirements of Curriculum IV., in addition to completing the graduate requirements. A candidate who is not giving his entire time to graduate study will be unable to earn the degree in one year's residence.

THESES

All Seniors are required to carry on special investigations during the second semester and the results of this work are embodied in a thesis. The subject of the thesis must be reported to the Thesis Committee of the Faculty and approved not later than January fifteenth. The completed thesis must be filed with the Director not later than May twentieth.

The finished thesis should be typewritten (or printed) on eight and one-half by eleven-inch paper, written on one side only. The paper should be strong linen, unruled and without marginal lines. The thesis should be typewritten so as to have a margin all around of not less than one and one-half inches.

The thesis should have:

(1) A title page containing the subject of the thesis, the writer's name, and the date. It should show the approval of the professor under whose direction the work has been done and should also state the degree for which the candidate is an applicant.
(2) A table of contents.
(3) A list of illustrations.
(4) The body of the thesis including illustrations.
(5) A bibliography.
(6) An index.
(7) Original drawings or tracings.

All theses submitted by candidates for degrees become the property of the School of Mines and Metallurgy and may not be published without the approval of the head of the department under whose direction the investigation was made.

I. MINE ENGINEERING CURRICULUM.

Department.	No.	Course.	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
FRESHMAN YEAR.						
First Semester.						
Chemistry	1a	General Chemistry	47	5	—	5
Chemistry	2a	Chemistry Laboratory	48	—	6	3
English	1a	Rhetoric and Composition	60	5	—	5
Mathematics	1a	College Algebra	69	5	—	5
Mathematics	3a	Plane Trigonometry	69			
Shop Practice and Draw'g	1a	Descriptive Geometry	97	3	—	3
Shop Practice and Draw'g	2a	Mechanical Drawing	97	—	6	3
Shop Practice and Draw'g	12a	Wood Work	98	—	6	3
Second Semester.						
Chemistry	1b	General Chemistry	47	5	—	5
Chemistry	3b	Qualitative Lectures	48	2	—	2
Chemistry	4b	Qualitative Laboratory	48	—	6	3
English	1b	Rhetoric and Composition	60	5	—	5
Mathematics	5b	Spherical Trigonometry	69	5	—	5
Mathematics	7b	Analytical Geometry	70			
Mining	1b	Mining	85	2	—	2
Shop Practice and Draw'g	2b	Mechanical Drawing	97	—	6	3
Shop Practice and Draw'g	14b	Forge Shop	98	—	6	3
SOPHOMORE YEAR.						
First Semester.						
Chemistry	5a	Quantitative Analysis	49	2	—	2
Chemistry	6a	Quantitative Laboratory	49	—	6	3
Civil Engineering	2a	Field Practice	53	—	9	5
English	3a	Technical Writing	60	2	—	2
Geology and Mineralogy	1a	Mineralogy	64	2	6	5
Mathematics	9a	Differential Calculus	70	4	—	4
Mathematics	11a	Integral Calculus	70			
Mining	3a	Mining	86	3	—	3
Modern Languages	7a	German	61	4	—	4
Modern Languages	9a	French, or	62			
Modern Languages	11a	Spanish	62			
Second Semester.						
Chemistry	6b	Quantitative Laboratory	49	—	9	4.5
English	3b	Technical Writing	61	2	—	2
Geology and Mineralogy	1b	Mineralogy	64	2	6	5
Mathematics	11b	Integral Calculus	70	5	—	5
Mathematics	13b	Differential Equations	70			
Mining	5b	Mine Surveying	86	2	—	2
Modern Languages	7b	German	62	4	—	4
Modern Languages	9b	French, or	62			
Modern Languages	11b	Spanish	62			
Physics	1b	General Physics	91	4	—	4
Physics	2b	Physics Laboratory	92	—	3	1.5
Mining	6	Mine Surveying, Field W'k	86	—	—	3
Civil Engineering	4	Topography	54	—	—	1.5

I. MINE ENGINEERING CURRICULUM.

Department.	No.	Course.	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
JUNIOR YEAR.						
First Semester.						
Civil Engineering	7a	Railroad Surveying	54	2	—	2
Civil Engineering	8a	Field Practice	55	—	3	1.5
Geology and Mineralogy	3a	General Geology	65	4	—	4
Geology and Mineralogy	5a	Lithology	66	1	3	2.5
Mathematics	15a	Statics	71	2	3	3.5
Mathematics	17a	Mechanics of Materials	71	2	—	2
Physics	3a	Physics	92	4	—	4
Physics	4a	Physics Laboratory	92	—	6	3
Physics	5a	Thermodynamics	92	3	—	3
Physics	6a	Steam Laboratory	93	—	3	1.5
Second Semester.						
Civil Engineering	9b	Hydraulics	55	3	—	3
Civil Engineering	10b	Hydraulic Problems	55	—	3	1.5
Civil Engineering	11b	Masonry	55	2	—	2
Geology and Mineralogy	3b	General Geology	65	4	—	4
Geology and Mineralogy	4b	Geology Laboratory	65	—	6	3
Mathematics	19b	Mechanics of Materials	71	2	—	2
Mathematics	20b	Materials Laboratory	71	—	3	1.5
Mathematics	21b	Dynamics	72	2	—	2
Metallurgy and Ore Dress'g	1b	Fire Assaying	75	2	—	2
Metallurgy and Ore Dress'g	2b	Assaying Laboratory	75	—	9	4.5
Metallurgy and Ore Dress'g	3b	General Metallurgy	76	3	—	3
Metallurgy and Ore Dress'g	31b	Elements of Ore Dressing	83	2	—	2
Mining	8	Junior Trip	86	—	—	4.5

SENIOR YEAR.

The entire Senior year of Curriculum I. is elective. Including 3 units thesis work, each candidate for a degree is required to complete 56 units work in addition to the required work of the first three years. The only restrictions on the choice of electives are the prerequisites for studies and the fixed schedule of hours. No conflicts whatever are permitted in the arrangement of the student's schedule.

Certain combinations of studies are possible as the schedule is arranged and certain groups are recommended for the students desiring to specialize along certain lines. A number of these groups follow:

MINING GEOLOGY. *First semester.* Petrography, Lectures and Laboratory; Geology of the United States; Economic Geology; Field Geology; Ore Dressing; Metallurgy; Mining Law; Mining Conference; Mining or Metallurgy Laboratory.

Second semester. Petrography, Lectures and Laboratory; Geology Conference; Economic Geology; Structural Geology; Ore Dressing, Lectures and Laboratory; Contracts; Mining; Mine Management; Thesis.

GENERAL MINING. *First semester.* Framed Structures and Graphics; Electrical Machinery, Lectures and Laboratory; Power Plant Laboratory; Ore Dressing, Lectures and Problems; Mining Law; Economic Geology; Metallurgy; Mining or Metallurgy Laboratory; and Mining or Metallurgy Conference.

Second semester. Compressed Air, Lectures and Laboratory; Electrical Machinery, Lectures and Laboratory; Power Plant Design; Ore Dressing, Lectures and Laboratory; Contracts; Mine Management; Metallurgy, or Economic Geology and Mining; Metallurgy Laboratory; Thesis.

COAL MINING. *First semester.* Framed Structures and Graphics; Electrical Machinery, Lectures and Laboratory; Power Plant Laboratory; Ore Dressing; Mining Law; Coal Mining; Mining Conference; Mining Laboratory; Railroad Economics; Engineering Design.

Second semester. Compressed Air, Lectures and Laboratory; Masonry Design and Drawing; Contracts; Electrical Machinery, Lectures and Laboratory; Fuel Testing; Power Plant Design; Mining; Mine Management; Economic Geology; Thesis.

II. METALLURGY CURRICULUM.

The Freshman Year in II. is the same as in I. See page 37.

Department.	No.	Course.	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
SOPHOMORE YEAR.						
First Semester.						
Chemistry	5a	Quantitative Analysis	49	2	—	2
Chemistry	6a	Quantitative Laboratory	49	—	6	3
Chemistry	7a	Physical Chemistry	50	2	—	2
Civil Engineering	2a	Surveying	53	—	9	5
English	3a	Technical Writing	60	2	—	2
Geology and Mineralogy	1a	Mineralogy	64	2	6	5
Modern Languages	7a	German	61			
Modern Languages	9a	French, or	62	4	—	4
Modern Languages	11a	Spanish	62			
Mathematics	9a	Differential Calculus	70			
Mathematics	11a	Integral Calculus	70	4	—	4
Second Semester.						
Chemistry	6b	Quantitative Laboratory	49	—	9	4.5
Chemistry	7b	Analytical Chemistry	50	2	—	2
English	3b	Technical Writing	61	2	—	2
Geology and Mineralogy	1b	Mineralogy	64	2	6	5
Modern Languages	7b	German	62			
Modern Languages	9b	French, or	62	4	—	4
Modern Languages	11b	Spanish	62			
Mathematics	11b	Integral Calculus	70			
Mathematics	13b	Differential Equations	70	5	—	5
Physics	1b	General Physics	91	4	—	4
Physics	2b	Physics Laboratory	92	—	3	1.5

II. METALLURGY CURRICULUM.

Department.	No.	Course.	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
JUNIOR YEAR.						
First Semester.						
Chemistry	9a	Electrochemistry	51	2	—	2
Chemistry	10a	Electrochemistry Lab.	51	—	3	1.5
Chemistry	8a	Quantitative Analysis	50	—	6	3
Geology and Mineralogy	3a	General Geology	65	4	—	4
Geology and Mineralogy	5a	Lithology	66	1	3	2.5
Mathematics	15a	Statics	71	2	—	2
Mathematics	17a	Mechanics of Materials	71	2	—	2
Physics	3a	Physics	92	4	—	4
Physics	4a	Physics Laboratory	92	—	6	3
Physics	5a	Thermodynamics	92	3	—	3
Physics	6a	Steam Laboratory	93	—	3	1.5
Second Semester.						
Chemistry	11b	Chemical Memoirs	51	2	—	2
Civil Engineering	9b	Hydraulics	55	3	—	3
Civil Engineering	10b	Hydraulic Problems	55	—	3	1.5
Geology and Mineralogy	3b	General Geology	65	4	—	4
Geology and Mineralogy	4b	Geology Laboratory	65	—	6	3
Mathematics	19b	Mechanics of Materials	71	2	—	2
Mathematics	21b	Dynamics	72	2	—	2
Metallurgy and Ore Dress'g	1b	Fire Assaying	75	2	—	2
Metallurgy and Ore Dress'g	2b	Assaying Laboratory	75	—	9	4.5
Metallurgy and Ore Dress'g	3b	General Metallurgy	76	3	—	3
Metallurgy and Ore Dress'g	31b	Elements of Ore Dressing	83	2	—	2
Mining	8	Junior Trip	86	—	—	4.5

II. METALLURGY CURRICULUM.

SENIOR YEAR.

The entire Senior year of Curriculum II. is elective. Prerequisites and the fixed schedule of hours for the semesters will govern in the selection of studies. Including three units thesis work, a total of fifty-six units must be completed for the Senior year. The following group of studies is recommended:

First semester. Electro-Metallurgy; Electrical Machinery, Lectures and Laboratory; Ore Dressing, Lectures and Laboratory; Alloys, Lectures and Laboratory; Metallurgy Lectures, Problems, Laboratory and Conference; Mining Law; Power Plant Laboratory.

Second semester. Compressed Air, Lectures and Laboratory; Electrical Machinery, Lectures and Laboratory; Contracts; Mine Management; Ore Dressing, Lectures and Laboratory; Cyaniding or Power Plant Design; Metallurgy, Lectures and Laboratory; Metallurgy Memoirs; Thesis.

The foregoing is planned for the student who wishes to pursue a general course in Metallurgy. Students desiring to specialize in Ore Dressing; Electro-Metallurgy: Metallurgy of Iron and Steel; Metallurgy of Gold; and Metallurgy of Lead or Metallurgy of Zinc, should consult with the Metallurgy Department before arranging the schedule of hours.

III. CIVIL ENGINEERING CURRICULUM.

The Freshman Year in III. is the same as in I. See page 37.

Department.	No.	Course.	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
SOPHOMORE YEAR.						
First Semester.						
Civil Engineering	2a	Surveying	53	—	9	5
Civil Engineering	5a	Topographical Drawing	54	—	6	3
English	3a	Technical Writing	60	2	—	2
Modern Languages	7a	German	61			
Modern Languages	9a	French, or	62	4	—	4
Modern Languages	11a	Spanish	62			
Mathematics	9a	Differential Calculus	70			
Mathematics	11a	Integral Calculus	70	4	—	4
Mining	3a	Mining	86	3	—	3
Physics	3a	Physics	92	4	—	4
Physics	4a	Physics Laboratory	92	—	6	3
Second Semester.						
Civil Engineering	3b	Higher Surveying	54	—	12	8
English	3b	Technical Writing	61	2	—	2
Geology and Mineralogy	2a	Mineralogy	64	—	3	2
Modern Languages	7b	German	62			
Modern Languages	9b	French, or	62	4	—	4
Modern Languages	11b	Spanish	62			
Mathematics	11b	Integral Calculus	70	5	—	5
Mathematics	13b	Differential Equations	70			
Mining	5b	Mine Surveying	86	2	—	2
Physics	1b	General Physics	91	4	—	4
Physics	2b	Physics Laboratory	92	—	3	1.5

III. CIVIL ENGINEERING CURRICULUM.

Department.	No.	Course.	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
JUNIOR YEAR.						
First Semester.						
Civil Engineering	7a	Railroad Surveying	54	2	—	2
Civil Engineering	8a	Field Practice	55	—	3	1.5
Civil Engineering	12a	Masonry	56	2	6	5
Geology and Mineralogy	3a	General Geology	65	4	—	4
Mathematics	15a	Statics	71	2	3	3.5
Mathematics	17a	Mechanics of Materials	71	2	—	2
Mathematics	20b	Materials Laboratory	71	—	3	1.5
Physics	5a	Thermodynamics	92	3	—	3
Physics	6a	Steam Laboratory	93	—	3	1.5
		Electives		3	—	3
Second Semester.						
Civil Engineering	9b	Hydraulics	55	3	—	3
Civil Engineering	10b	Hydraulic Problems	55	—	3	1.5
Civil Engineering	12b	Masonry	56	2	6	5
Civil Engineering	13b	Roads and Pavements	56	3	—	3
Civil Engineering	14b	Engineering Laboratory	56	—	6	3
Geology and Mineralogy	6b	Geology Laboratory	66	—	3	1.5
Mathematics	19b	Mechanics of Materials	71	2	—	2
Mathematics	21b	Dynamics	72	2	—	2
Metallurgy and Ore Dress'g	3b	General Metallurgy	76	3	—	3
		Electives		3	—	3
SENIOR YEAR.						
First Semester.						
Civil Engineering	17a	Contracts	57	1	—	1
Civil Engineering	15a	Frame Structures	56	2	—	2
Civil Engineering	16a	Engineering Design	57	—	9	4.5
Civil Engineering	19a	Water Supply	57	5	—	5
Civil Engineering	21a	Irrigation	57	3	—	3
Civil Engineering	23a	Railroad Economics	58	3	—	3
Physics	7a	Electrical Machinery	93	3	—	3
Physics	8a	Dynamo Laboratory	93	—	3	1.5
Physics	16a	Power Plant Tests	94	—	3	1.5
Second Semester.						
Civil Engineering	25b	Bridges	58	5	—	5
Civil Engineering	27b	Compressed Air	58	2	—	2
Civil Engineering	28b	Compressed Air Lab	58	—	3	1.5
Civil Engineering	29b	Sanitary Engineering	59	5	—	5
Civil Engineering	31b	Masonry Design	59	3	—	3
Civil Engineering	32b	Masonry Design Practice	59	—	3	1.5
Physics	7b	Electrical Machinery	93	3	—	3
Physics	8b	Dynamo Laboratory	93	—	3	1.5
		Thesis		—	6	3

IV. GENERAL SCIENCE CURRICULUM.

The Freshman Year in IV. is the same as in I. See page 37.

Department.	No.	Course.	Page	Hours Per Week		Hours Credit
				Lect.	Lab.	
SOPHOMORE YEAR.						
First Semlster.						
English	3a	Technical Writing	60	2	—	2
Geology and Mineralogy	1a	Mineralogy	64	2	6	5
Modern Languages	*	Modern Languages	61	4	—	4
		Electives		7	12	13
Second Semester.						
English	3b	Technical Writing	61	2	—	2
Geology and Mineralogy	1b	Mineralogy	64	2	6	5
Modern Languages	*	Modern Languages	61	4	—	4
Physics	2b	Physics Laboratory	92	—	3	1.5
		Electives		7	9	11.5
JUNIOR YEAR.**						
First Semester.						
English	5a	18th Century Prose	61	3	—	3
Geology and Mineralogy	3a	General Geology	65	4	—	4
Modern Languages	*	Modern Languages	61	4	—	4
Physics	3a	General Physics	92	4	—	4
Physics	4a	General Physics Lab.	92	—	6	3
		Electives		6	12	12
Second Semester.						
English	5b	Shakespeare	61	3	—	3
Geology and Mineralogy	3b	General Geology	65	4	—	4
Geology and Mineralogy	4b	General Geology Lab.	65	—	6	3
Modern Languages	*	Modern Languages	61	4	—	4
		Electives		10	12	16

SENIOR YEAR.**

Subjects All Elective.—Nineteen hours of recitation and eighteen hours of laboratory work must be elected each semester. In the second semester six hours a week thesis work is to be included in the laboratory time.

All electives throughout the course must be chosen, with the approval of the faculty, from one of the following groups:

Physics-Mathematics, Chemistry-Mathematics, Physics-Chemistry-Mathematics, Chemistry-Metallurgy, Chemistry-Geology, Geology-Mining, Mining-Metallurgy.

*Two modern foreign languages are required in the General Science Curriculum. Either French, German, or Spanish may be elected for two semesters work.

**Candidates for degrees in General Science must matriculate in the General Science Curriculum not later than the beginning of the Junior year.

V. GRADUATE CURRICULUM IN MINE ENGINEERING.

Graduates of this or other institutions of equal rank who have received the degree of Bachelor of Science in Mine Engineering may matriculate for a course of graduate study and research in Mine Engineering. The minimum requirement is the completion of fifty-six units work including a thesis.

Candidates for degrees must give half their time to work upon a major subject which must be in the Department of Mining, Geology, or Metallurgy and Ore Dressing. At least one-fourth of the work must be done in one of the other departments noted above. The major and the minor subjects must be approved by the Faculty before the student enters upon the work. A suitable thesis subject must be approved.

VI. GRADUATE CURRICULUM IN METALLURGY.

Graduates of this school or of other institutions of equal rank who have completed a course of study leading to the degree of Bachelor of Science in Metallurgy may undertake advanced work leading to the degree of Metallurgical Engineer. The minimum requirement is fifty-six units work including a thesis.

Candidates for the degree of Metallurgical Engineer must give half their time to work upon a major subject in the Department of Metallurgy and Ore Dressing. At least fourteen units work shall be upon a minor subject in another department. The major, the minor, and the thesis subjects must be approved by the faculty.

VII. GRADUATE CURRICULUM FOR ENGINEERS.

Graduates in Civil, Electrical, and Mechanical Engineering may become candidates for the degree of Engineer of Mines upon the completion of two years' work (112 units), in residence at this institution.

The student will be required to complete or to present credits for all of the subjects outlined for the first three years of the course in Mine Engineering and will be expected to earn or present credits in a total of one hundred twelve units above the Junior year, and take all of the trips required in the Mine Engineering Curriculum.

Attention is directed to the list of studies on page 32. Work will be arranged in Mine Engineering, Metallurgy, Ore Dressing, and Geology for students who desire to specialize along some particular line. Research work must be carried on during the second semester of the second year and a thesis must be submitted.

VIEW ON CAMPUS

CHEMISTRY

Professor Gottschalk, Assistant Professor Test, Mr. Knickerbocker, Mr. Ingram, Mr. Copelin, Mr. Kelly, Mr. Lane.

Equipment.

One entire building is given to chemistry. The main chemical lecture room occupies the entire south wing of the building. The laboratories for general chemistry and for qualitative analysis, on the first floor of the main building, accommodate together about one hundred forty students. The quantitative laboratories on the second floor have desk room for seventy-five students working at one time. In the north wing is a smaller lecture room, as well as a capacious laboratory for advanced students.

Excellent ventilation is provided by a thirteen-horsepower motor and suction fan connected with individual hoods over each laboratory desk and with the long lines of fume chambers distributed throughout the building. Gas, water, and air blast are supplied conveniently, while a steam-heated still of five gallons an hour capacity furnishes ample distilled water.

The equipment includes twenty-four first-class analytical balances, sixty sets of good analytical weights, sixty sets of volumetric instruments with Bureau of Standards stamps, a liberal supply of platinum ware, and a good selection of precision instruments for physico-chemical and electro-chemical measurements.

Courses.

1a. GENERAL CHEMISTRY. *Lectures.* (Test)

This course is a comprehensive study of the general principles of chemistry and of the more important non-metals. The ionic theory, phase rule, and mass-law are introduced, and applied at advantageous points in the lectures. Special stress is laid on experimental demonstrations. The class is divided into several smaller sections for recitation and discussion of problems.

Prerequisites: Entrance requirements.

Required in I., II., III., and IV.

Freshman year, first semester, five hours per week. Credit five hours.

Text: Kahlenberg, *Outlines of Chemistry.*
Hale, *Calculations of General Chemistry.*

1b. GENERAL CHEMISTRY. *Lectures.* (Test)

Continuation of course 1a; devoted to the chemistry of the metals, with special consideration of the reactions employed in analytical chemistry, in metallurgy, and in geology. The Periodic Law is followed throughout.

Prerequisites: Chemistry 1a and 2a.

Required in I., II., III., and IV.

Freshman year, second semester, five hours per week. Credit five hours.

Text: Kahlenberg, *Outlines of Chemistry.*

2a. GENERAL CHEMISTRY. *Laboratory.*
(Test, Knickerbocker, Ingram)

The laboratory work accompanying general chemistry consists of experiments which are largely quantitative, and which are intended to teach stoichiometrical relations from the first.

Prerequisite. Must be accompanied by Chemistry 1a.

Required in I., II., III., and IV.

Freshman year, first semester, six hours per week. Credit three hours.

Text: Ransom, *Experimental General Chemistry.*

3b. QUALITATIVE ANALYSIS. *Lectures.* (Test)

This course is an exposition of the principles underlying the qualitative separation and identification of the commoner elements found in minerals, rocks, and metallurgical products.

Prerequisites: Chemistry 1a and 2a and accompanied by 1b.

Required in I., II., III., and IV.

Freshman year, second semester, two hours per week. Credit two hours.

Text: Bailey and Cady, *Qualitative Analysis.*

4b. QUALITATIVE ANALYSIS. *Laboratory.*
(Test, Knickerbocker, Ingram)

The student is drilled in the practical separation and identification of ordinary mineral constituents, the examples for practice being limited to solutions or mixtures soluble in acids. While the wet methods are preferred, the ordinary blowpipe tests and spectroscopic methods are also taught; very little attention is paid to tests for acids.

Prerequisite: Chemistry 2a, and must be accompanied by 3b.

Required in I., II., III., and IV.

Freshman year, second semester, six hours a week. Credit three hours.

Text: Bailey and Cady, *Qualitative Analysis.*

5a. QUANTITATIVE ANALYSIS. *Lectures.* (Gottschalk)

The subjects discussed in this course are as follows: The preparation for analysis of minerals, rocks, and metallurgical products; qualitative detection of the impurities present in such substances; the balance, weights, and the process of weighing; simple gravimetric analysis; analysis of silicate rocks, and application to clay, shale, and slag analysis; volumetric instruments, their calibration and use; volumetric analysis, standard solutions, indicators; technical volumetric methods in general wet assaying of copper, zinc, and lead ores and concentrates. Problems in the calculations of analytical chemistry are also discussed.

Prerequisites: Chemistry 3b, 4b.

Required in I. and II.

Sophomore year, first semester, two hours per week. Credit two hours.

Text: *Manuscript Notes.*
Miller, *Calculations of Analytical Chemistry.*

6a. QUANTITATIVE ANALYSIS. *Laboratory.*
(Gottschalk, Copelin, Kelly)

Practice in the preparation for analysis of minerals, ores, and metallurgical products, and their qualitative analysis with especial reference to elements present in smaller quantities; given as a continuation of the course in qualitative analysis and as an introduction to the following technical analysis. Before beginning actual quantitative analysis, the student is required to make a careful study of the balance and of the method of weighing. The rest of the time is given to exercises in simple gravimetric analysis, with some volumetric analysis, chiefly on analyzed mixtures, closing with a (technical) clay analysis.

Prerequisites: Chemistry 3b, 4b, and must be accompanied by 5a.

Required in I. and II.

Sophomore year, first semester, six hours per week. Credit three hours.

Text: Miller, *Quantitative Analysis for Mining Engineers.*
Miller, *Calculations of Analytical Chemistry.*

6b. QUANTITATIVE ANALYSIS. *Laboratory.*
(Gottschalk, Copelin, Ingram)

Technical methods for the determination of copper, lead, zinc, arsenic, antimony, sulphur, and coal analysis. Essential parts of the course are the speed tests, in which students are required to report correct results on a number of copper, zinc, and lead ores within a stated time.

Actual ores, analyzed by the instructing staff, are on hand in

large quantity, and the students are trained to attain the same degree of accuracy which obtains in smelter laboratories.

Prerequisite: Chemistry 6a.

Required in I. and II.

Sophomore year, second semester, nine hours per week. Credit 4.5 hours.

Text: Seamon, *Manual for Assayers and Chemists.*

7a. PHYSICAL CHEMISTRY. *Lectures.* (Test)

This course is intended as an introduction to physical chemistry. The qualitative and quantitative theories of chemical equilibria as given by the phase rule and by the mass law are studied first. Towards the end of the term the basis of the ionic theory is discussed.

Prerequisite: Chemistry 4b.

Required in II.

Sophomore year, first semester, two hours per week. Credit two hours.

Text: Walker, *Introduction to Physical Chemistry.*

7b. ANALYTICAL CHEMISTRY. *Lectures.* (Gottschalk)

The application of the ionic theory to analytical chemistry is taken up in detail; a select number of lecture experiments illustrate the main propositions advanced.

Prerequisite: Chemistry 7a.

Required in II.

Sophomore year, second semester, two hours per week. Credit two hours.

Text: Ostwald, *Foundations of Analytical Chemistry.*

8a. QUANTITATIVE ANALYSIS. *Laboratory.* (Gottschalk)

This course is offered primarily for students of metallurgy who desire to become acquainted with the methods of analysis of mattes, speisses, crude and refined lead and copper bullion, spelter, alloys, and similar material. No required schedule is laid out; students are strongly recommended to employ some of this time in elementary physico-chemical measurements, as this subject has become nearly indispensable in their branch.

Prerequisite: Chemistry 6b.

Required in II.

Junior year, first semester, six hours per week. Credit three hours.

9a. ELECTRO-CHEMISTRY. *Lectures.* (Gottschalk)

The course opens with a brief theoretical introduction to the Nernst theory. The main object of the lectures is the application to the theory of the deposition of metals out of aqueous solutions as practiced in electro-metallurgy.

Prerequisite: Chemistry 7b.

Required in II.

Junior year, first semester, two lectures per week. Credit two hours.

Text: *Manuscript Notes.*

10a. ELECTRO-CHEMISTRY. *Laboratory.* (Gottschalk)

The practical work consists of the measurement of electrolytic conductances and of single differences of potential, followed by experiments on the relation between the electrode potential and current density, and on the electrolytic refining of metals.

Prerequisite: Must be accompanied by Chemistry 9a.

Required in II.

Junior year, first semester, three hours per week. Credit 1.5 hours.

Text: *Manuscript Notes.*

11b. CHEMICAL MEMOIRS. *Class-Room Work.* (Gottschalk)

Carefully prepared abstracts of current articles or of special subjects are prepared by the student for this course.

Prerequisite: Chemistry 9a.

Required in II.

Junior year, second semester, two hours per week. Credit two hours.

Elective and Graduate Courses.

12b. WATER ANALYSIS. *Laboratory.* (Test)

This course is designed to meet the wants of engineering students. Sanitary water analysis and boiler water analysis are offered, although students interested in geology may substitute mineral water analysis for some of the work.

Prerequisite: Chemistry 6a.

Elective, second semester, six hours per week. Credit three hours.

13a. THEORETICAL CHEMISTRY. *Lectures.* (Gottschalk)

The applications of theoretical chemistry to fundamental metallurgical principles are assuming such prominence and leading to such important results that a knowledge of this subject is indispensable to the metallurgical engineer who desires to keep pace with

the developments in this field. To meet this demand a course for graduate students is offered, presenting the subject of chemical equilibria from the thermodynamic point of view, including a consideration of the technical applications made by Nernst, Le Chatelier, Haber, von Jueptner and others. The student is expected to do considerable reading of original articles in English, German, and French scientific journals and books.

Prerequisites: Chemistry 9a, Mathematics 15a and 17a, and Physics 5a.

Graduate course, first semester, two lectures per week. Credit two hours.

13b. THEORETICAL CHEMISTRY. *Lectures.* (Gottschalk)

Continuation of Chemistry 13a.

Second semester, two lectures per week. Credit two hours.

Reference: Nernst, *Theoretical Chemistry.*

14b. ADVANCED CHEMISTRY. *Laboratory.* (Gottschalk)

This is an advanced course to accompany the lectures in Theoretical Chemistry, and includes the study and measurements of typical chemical equilibria, either as a repetition of classical researches in this field, or preferably on original problems. The equipment for this work includes measuring instruments of the most approved types for high temperature, electro-thermic and physico-chemical work, and special apparatus built in the school shops.

Prerequisite: Must be accompanied by Chemistry 13b.

Second semester, six hours per week. Credit three hours.

CIVIL ENGINEERING.

PROFESSOR HARRIS, MR. MCCANDLISS, MR. NEEDLES.

Equipment.

On the third floor of Norwood Hall are located three large well-lighted and well-equipped drafting rooms, two lecture rooms, and a department library and study.

The equipment for field practice includes twenty-eight transits, one theodolite, twelve plane tables, one solar compass, seven railroad compasses, eleven levels, two sextants, together with barometers, telemeters, hook gage, and current meter, chains, tapes, level rods, and other necessary equipment for field practice. A number of transits are equipped with solar attachments and others with attachments for underground work. The instrument room is equipped with separate lockers for the equipment of each surveying squad.

A well-lighted laboratory is equipped with the necessary apparatus for cement testing and proportioning and testing concrete.

In the power plant are one duplex single-stage air compressor, one compound two-stage air compressor, and one centrifugal pump so arranged that it can be operated as a two-stage or as a single-stage pump. With these there are provided the necessary gages, orifices, indicators, etc., to make complete tests.

Courses.

2a. SURVEYING. *Field Work and Lectures.*
(McCandliss, Needles)

A general course in surveying including the adjustments, uses, and limitations of transits, levels, and the minor instruments. Students are drilled in traversing, computing areas, establishing meridians, city surveying, topographic methods, triangulating, and precise leveling.

A strict standard is enforced in the form and style of the student's field record.

Prerequisites: Mathematics 1a, 3a, 5b, 7b.

Required in I., II., and III.

Sophomore year, first semester, three afternoons per week. Credit five hours.

Text: Johnson and Smith, *Theory and Practice of Surveying.*

3b. HIGHER SURVEYING. *Lectures and Field Practice.*
(McCandliss, Needles)

A course embracing descriptive astronomy, with special attention to the determination of azimuth, altitude, latitude, longitude and time; and the theory of base line measurements, precise triangulation, and the construction of geographical charts.

Field work and problems are given to accompany the lecture work.

Prerequisite: Civil Engineering 2a.

Required in III.

Sophomore year, second semester, twelve hours per week. Credit eight units.

4. TOPOGRAPHY. *Field Work.*
(Harris, McCandliss, Needles)

An effort is made in this course to execute a complete topographical survey of a small area in the Ozark Mountains, presenting a wide range of conditions, in which practice is afforded in the methods applicable to such work, employing the use of the stadia, plane table and other instruments in so far as the time will permit.

Prerequisite: Civil Engineering 2a.

Required in I.

Summer vacation, one week preceding first semester, Junior year. Credit 1.5 hours.

5a. TOPOGRAPHICAL DRAWING. *Laboratory.*
(McCandliss)

This course is designed to represent conditions of actual practice in office and drafting room. Especial stress is laid on neatness, accuracy, and dispatch. The course covers practice in free-hand lettering for titles, etc., topographical signs and the platting of traverses by different methods.

Prerequisites: Civil Engineering 2a, Shop Practice and Drawing 2b.

Required in III.

Sophomore year, first semester, two afternoons per week. Credit three hours.

7a. RAILROAD SURVEYING. *Lectures.* (McCandliss)

Covers the mathematical problems in the location, construction, and maintenance of railways, highways, and canals, and in setting out and estimating earthwork.

Prerequisite: Civil Engineering 2a.

Required in I. and III.

Junior year, first semester, two hours per week. Credit two hours.

Text: Nagle, *Field Manual for Railroad Engineers.*

8a. FIELD PRACTICE. (McCandliss, Needles)

Supplementary to the lectures in lines of communication. Typical problems and methods presented in the text are executed in the field in such a way as to give the student confidence in the methods and in his own ability.

Prerequisite: Civil Engineering 3a.

Required in I. and III.

Junior year, first semester, one afternon per week. Credit 1.5 hours.

9b. HYDRAULICS. *Lectures.* (Harris)

The theory of hydrostatics and of hydraulics and application to the dependent problems in engineering practice, such as the determination of empirical coefficients and their application in determining the flow of water through orifices, weirs, pipes, canals, and rivers. Also the theory of hydraulic motors and dynamic pumps and the practice with such machines.

Prerequisite: Mathematics 15a.

Required in I., II., and III.

Junior year, second semester, three hours per week. Credit three hours.

Text: Merriman, *Hydraulics.*

10b. HYDRAULIC PROBLEMS. *Laboratory.* (Harris)

One afternoon per week is assigned to the solution of problems in hydraulics and hydrostatics under the direction of the instructor. This includes the testing of the hydraulic equipment of the school, including the air-lift pump.

Prerequisite: To accompany Civil Engineering 9b.

Required in I., II., and III.

Junior year, second semester, one afternon per week. Credit 1.5 hours.

11b. MASONRY CONSTRUCTION. *Lectures.* (McCandliss)

This course teaches the principles governing the design of foundations and retaining walls, the principles and practice of plain and reinforced concrete construction, reports on existing masonry structures.

Prerequisite: Mathematics 15a. To be accompanied by Mathematics 17b.

Required in I.

Junior year, second semester, two hours per week. Credit two hours.

Text: Baker, *Masonry Construction.*

12a. MASONRY CONSTRUCTION. *Lectures and Laboratory.*
(McCandliss)

A course covering the economics of building material; the theory and design of foundations; retaining walls; plain and reinforced concrete; and arches.

Prerequisites: To be accompanied by Mathematics 15a and 17a.
Required in III.
Junior year, first semester, two lectures and two laboratories per week. Credit five hours.
Text: Baker, *Masonry Construction.*

12b. MASONRY CONSTRUCTION. *Lectures and Laboratory.*
(McCandliss)

A continuation of Course 12a.
Prerequisite: To be preceded by 12a.
Required in III.
Junior year, second semester, two lectures and two laboratories per week. Credit five hours.
Text: Baker, *Masonry Construction.*

13b. ROADS AND PAVEMENTS. *Lectures.*
(McCandliss)

This course is intended to treat of the economic properties of road materials; the location, construction, and maintenance of roads and streets; types of improvements; designs and estimates of cost.
Prerequisites: Mathematics 15a. To be accompanied by Mathematics 17b and Civil Engineering 11b, or 12a and 12b.
Required in III.
Junior year, second semester, three hours per week. Credit three hours.

14b. ENGINEERING LABORATORIES. *Laboratory.*
(Harris, McCandliss)

A course designed to give the student an experimental knowledge of the properties of cements and cement mortars; standard cement tests; proportioning and testing of concrete.
Prerequisites: Supplementary to Civil Engineering 9b; 11b, or 12a and 12b; and 13b.
Required in III.
Junior year, second semester, two afternoons per week. Credit three hours.

15a. FRAMED STRUCTURES. *Lectures.* (Harris)

Treats of general methods of determining stresses in such structures as single-span bridges, roofs, towers, three-hinged

arches, etc., and of the design of individual members, such as beams, posts, and rods, to carry the determined stresses.

Prerequisite: Mathematics 17b.

Required in III.

Senior year, first semester, two hours per week. Credit two hours.

16a. ENGINEERING DESIGNING. *Laboratory.* (Harris)

The student working under the direction of the instructor works out the design of as many structures as time permits. The work includes making the necessary computations, finished drawings, and specifications.

Prerequisites: Supplementary to Civil Engineering 15a, 19a, and 21a.

Required in III.

Senior year, first semester, two afternoons per week. Credit three hours.

17a. CONTRACTS. *Lectures.* (Harris)

A lecture course in the laws of contracts, and the preparation of specifications.

Required in III.

Senior year, first semester, one hour per week. Credit one hour.

Text: Tucker, *Contracts in Engineering.*

19a. WATER SUPPLY. *Lectures.* (Harris)

Covers the selection, storing, transporting, purification, and delivering water to cities and towns.

Prerequisites: Civil Engineering 9b and 11b.

Required in III.

Senior year, first semester, five hours per week. Credit five hours.

Text: Turneaure and Russell, *Water Supply.*

21a. IRRIGATION ENGINEERING AND RIVER AND HARBOR IMPROVEMENTS. *Lectures.* (Harris)

The time here allotted is given to the study of special problems arising in the design of irrigation projects, such as location of the main canal and its head works, mapping the lands, locating the secondary canals, special methods of measuring and delivering the water, necessary water consumption, etc., and to the study of the cause and control of floods, protection of river banks, improvement of navigation, and protection and improvement of harbors.

Prerequisites: Civil Engineering 9b and 11b.

Required in III.

Senior year, first semester, three hours per week. Credit three hours.

23a. Railroad Economics. *Lectures.* (Harris)

Treats of the economic principles involved in railway location and of improvement of old lines as affected by curvature, grades, first cost, cost of maintenance, and traffic.

Prerequisite: Civil Engineering 7a.

Required in III.

Senior year, first semester, three hours per week. Credit three hours.

Text: Beahan, *Field Practice of Railway Location.*

25b. BRIDGES (HIGHER STRUCTURES). *Lectures.* (Harris)

Covers the study of effects of concentrated wheel loads on simple bridges and the study of cantilever, swing and suspension bridges and elastic arches.

Prerequisite: Civil Engineering 15a and 16a.

Required in III.

Senior year, second semester, five hours per week. Credit five hours.

Text: Johnson, *Framed Structures.*

27b. COMPRESSED AIR. *Lectures.* (Harris)

Covers the theory of air compression, measurement and transmission, and the practical application in the industries.

Prerequisites: Civil Engineering 9b, Mathematics 17b, and Physics 5a.

Required in III.

Senior year, second semester, two hours per week. Credit two hours.

Text: Harris, *Compressed Air.*

28b. COMPRESSED AIR LABORATORY. *Laboratory.* (Harris)

The students are required to examine, dissect, and adjust the air compressors in the school equipment, and to determine their volumetric and mechanical efficiency. Tests are made determining the frictional loss in air pipes, elbows, etc., and output and efficiency of centrifugal blowers and fans.

Prerequisite: Supplementary to Civil Engineering 27b.

Required in III.

Senior year, second semester, three hours per week. Credit 1.5 hours.

29b. SANITARY ENGINEERING. *Lectures.* (Harris)

Treats of the precautions necessary to protect water supplies from pollution and the methods available for purification of sewage. Also the construction of sewer systems for the collection and transportation of sewage and storm waters.

Prerequisite: Civil Engineering 19a.

Required in III.

Senior year, second semester, five hours per week. Credit five hours.

Text: Followell, *Sewage of Cities.*

31b. MASONRY DESIGNS AND CONCRETE STEEL. *Lectures.* (Harris)

Treats of the higher structures in masonry, such as high masonry dams, concrete steel dams, arches, and full theoretic and practical study of concrete steel construction.

Prerequisites: Civil Engineering 11b, 15a, and 25b.

Required in III.

Senior year, second semester, three hours per week. Credit three hours.

32b. MASONRY DESIGNS—PRACTICE. *Laboratory.* (Harris)

The theories developed in Civil Engineering 31b are here applied in the complete design of as many structures as the time will permit. Specifications for one or more structures are required.

Prerequisite: Supplementary to Civil Engineering 31b.

Required in III.

Senior year, second semester, three hours per week. Credit 1.5 hours.

ENGLISH AND MODERN FOREIGN LANGUAGES.

Assistant Professor Barley, Mr. Wilkins, Mr. Scott.

ENGLISH.

1a. RHETORIC AND COMPOSITION. *Lectures.* (Scott)

Lectures on the theory of exposition and description, and the study of literature illustrative of these forms. A large amount of written work is required of the student in order that he may gain facility in the use of clear, idiomatic English. As far as possible this written work is drawn from other courses pursued by the student, thereby correlating his practice in composition with his immediate interests and activities.

Prerequisites: Entrance requirements.

Required in all courses.

Freshman year, first semester, five hours a week. Credit five hours.

Texts: Berkeley, *College Course in Writing from Models.*
Wooley, *Mechanics of Writing.*
Canby, *English Composition in Theory and Practice.*
The Atlantic Monthly.

Note. Students who show lack of ability to do the work of the course will be dropped from the class after six weeks.

1b. RHETORIC AND COMPOSITION. *Lectures.* (Scott)

This course is a continuation of 1a.

Prerequisite: 1a.

Required in all courses.

Freshman year, second semester, five hours a week. Credit five hours.

3a. TECHNICAL WRITING. *Lectures.* (Barley)

The problems of engineering writing and the mechanical details of technical writing.

Prerequisites: 1a and 1b.

Required in all courses.

Sophomore year, first semester, two hours a week. Credit two hours.

Texts: Sypherd, *English for Engineers.*
Earle, *Theory and Practice of Technical Writing.*

POWER PLANT

3b. TECHNICAL WRITING. *Lectures.* (Barley)

Course 3a continued.

Prerequisite: 3a.

Required in all courses.

Sophomore year, second semester, two hours a week. Two credits.

Texts: As in 3a.

5a. EIGHTEENTH CENTURY PROSE. *Lectures.* (Barley)

Studies in DeFoe, Swift, Addison, Steele, Johnson, Goldsmith, Burke, and other prose writers of the period. A large amount of collateral reading is required.

Prerequisites: English 3a and 3b.

Required in IV.

Junior year, first semester, three hours a week. Credit three hours.

5b. SHAKESPEARE AND HIS CONTEMPORARIES. *Lectures.* (Barley)

A reading course in Elizabethan drama, preceded by a consideration of the development of English drama from its origin through the miracle, morality and interlude into regular drama. Altogether about twenty plays are read, and some of the problems incident to the period are investigated.

Prerequisites: 3a and 3b.

Required in IV.

Junior year, second semester, three hours a week. Credit three hours.

MODERN FOREIGN LANGUAGES.

Candidates for degrees in Curricula I., II., and III, are required to complete two semesters' work in either French, German, or Spanish. Candidates for degrees in Curriculum IV. are required to complete two semesters' work in each of any two of the modern foreign languages offered, namely, French, German, or Spanish.

7a. SCIENTIFIC GERMAN. *Lectures.* (Wilkins)

Prerequisite: One year of elementary German and English 1a and 1b.

Sophomore year, first semester, four hours a week. Credit four hours.

Texts: Wallentin, *Grundzüge der Naturlehre.*
Current Scientific Journals and Magazines.

7b. SCIENTIFIC GERMAN. *Lectures.* (Wilkins)

A continuation of 7a.

Prerequisite: 7a.

Sophomore year, second semester, four hours a week. Credit four hours.

Texts: *Current Scientific Journals and Magazines.*

9a. SCIENTIFIC FRENCH. *Lectures.* (Barley)

Prerequisite: One year of elementary French and English 1a and 1b.

Sophomore year, first semester, four hours a week. Credit four hours.

Texts: Bowen, *Scientific French Reader.*
Dike, *Scientific French Reader.*
Current Scientific Journals and Magazines.

9b. SCIENTIFIC FRENCH. *Lectures.* (Barley)

Prerequisite: As in 9a.

Sophomore year, second semester, four hours a week. Credit four hours.

Texts: As in 9a.

11a. ELEMENTARY SPANISH. *Lectures.* (Wilkins)

Prerequisites: English 1a and 1b.

Sophomore year, first semester, four hours a week. Credit four hours.

Text: Wagner, *Spanish Grammar.*

11b. SPANISH. *Lectures.* (Wilkins)

This course is a continuation of 11a.

Prerequisites: 11a.

Sophomore year, second semester, four hours a week. Credit four hours.

Text: As in 11a.

GEOLOGY AND MINERALOGY.

Professor Cox, Assistant Professor Eggleston, Mr. McNutt.

Equipment.

The geological and mineralogical laboratories are on the second floor of Norwood Hall. They are supplied with suitable tables for the examination of rocks and minerals. The equipment of the department includes reference, working, and cabinet collections of minerals, ores, rocks, and fossils and many specimens illustrating metallurgical processes; a working collection of wooden and glass crystal models and natural crystals; full sets of maps and reports and a set of geological relief models.

There is also a collection of thirty-five hundred specimens, representing the mineral wealth of Missouri, consisting of coal, clays of many sorts, building stones, and ores of lead, zinc, iron, and copper. The minerals occurring as gangue with the metalliferous deposits of the State are also well represented. There is also a complete collection of the economic minerals of Missouri and a good economic geological collection representing the world at large. This collection was a part of the Missouri Mineral Exhibit displayed at the World's Fair at Chicago and was presented to the School of Mines and Metallurgy by the General Assembly in 1895.

In addition to the above-mentioned collection, the State Board of Equalization assigned to the School the specimens, models, maps, and machinery which constituted the Missouri Mining Exhibit at the St. Louis Exposition, thus giving to the School a large amount of valuable equipment.

The Museums contain crystals and minerals from various parts of the world, the important mining districts of the State of Missouri being especially well represented by the economic collection from Southwestern Missouri, the great geological relief map, polished stone tables and ornamental stones, and other complete collections of the Missouri Building of the St. Louis Exposition.

Rock breaking and section machines and instruments for geological surveys are included in the equipment of this department.

MINERALOGY.

Courses.

1a. MINERALOGY. *Lectures and Laboratory.*
(Eggleston, McNutt)

Elementary crystallography, including the study of models and natural crystals, with oral and written recitations, ten weeks; practice in blowpipe analysis with determination of unknowns, four weeks; introduction to descriptive and determinative mineralogy the remainder of the semester.

Prerequisites: Chemistry 1a, 2a, 3b, 4b, and Shop Practice and Drawing 1a.

Required in I., II., and IV.

Sophomore year, first semester, two hours' lectures and six hours' laboratory per week. Credit five hours.

Texts: Patton, *Lecture Notes on Crystallography.*
Butler, *Handbook of Blowpipe Analysis.*
Dana, *Text-Book of Mineralogy.*

1b. MINERALOGY. *Lectures and Laboratory.*
(Eggleston, McNutt)

Descriptive and determinative mineralogy. A study of the fundamental principles of classification and the distinctive characters of minerals with a thorough drill in the recognition of about two hundred species. Recitations mostly oral.

Prerequisite: Mineralogy 1a.

Required in I., II., and IV.

Sophomore year, second semester, two hours' lectures and six hours' laboratory per week. Credit five hours.

Text: Dana, *Text-Book of Mineralogy.*

2a. C. E. MINERALOGY. *Laboratory.* (McNutt)

A study of the common ore and rock forming minerals and types of rocks. The necessary lectures are given during the regular laboratory periods. This course is intended for the Civil Engineering students, the same ground being covered more thoroughly by Courses 1a, 1b, and 5a, so that full credit may not be given for it and one or more of these courses, and it may not be substituted for any part of them.

Prerequisites: Chemistry 1a, 1b, 2a, 3b, and 4b.

Required in III.

Sophomore year, second semester, three hours per week. Credit two hours.

11a. OPTICAL MINERALOGY. See Geology 11a.

GEOLOGY.

Courses.

3a. GENERAL GEOLOGY. *Lectures.* (Eggleston)

Dynamic geology. A somewhat detailed account of geologic processes. The larger topics are treated more exhaustively than in the required text. Local field trips.

Prerequisites: Mineralogy 1a and 1b.

Required in I., II., III., and IV.

Junior year, first semester, four hours per week. Credit four hours.

Text: Scott, *An Introduction to Geology.*

3b. GENERAL GEOLOGY. *Lectures.* (Eggleston)

Introductory structural and historical geology. Typical geologic structures and their effects upon the physiographic development of the earth's surface are considered for the first six weeks. Geologic history is then traced from the beginning of the record to the present, as much attention as possible being paid to the rock-systems and their contained fossils, with some reference to geographic changes and organic evolution.

Prerequisites: Geology 3a. To be accompanied by Geology 4b.

Required in I., II., III., and IV.

Junior year, second semester, four hours per week. Credit four hours.

Text: Scott, *An Introduction to Geology.*

4b. GENERAL GEOLOGY. *Laboratory.* (Eggleston)

Laboratory exercises in reading topographic and geologic maps; in the construction of profile and geologic sections and simple geologic maps; in the interpretation of significant textures and structures in rocks; and in the recognition of twenty index fossils. These exercises are designed to illustrate the subject-matter of the earlier lectures of Course 3b, and occupy nine weeks; excursions and field practice in elementary geologic mapping the remainder of the semester.

Prerequisite: Geology 3a. To accompany Geology 3b.

Required in I., II., III., and IV.

Junior year, second semester, six hours per week. Credit three hours.

References: Hayes, *Handbook for Field Geologists.*
Geikie, *Outlines of Field Geology.*

5a. LITHOLOGY. *Lectures and Laboratory.* (McNutt)

A study of the structure, texture, mineral and chemical composition, and the manner of formation and occurrences of igneous, sedimentary, and metamorphic rocks. This course is adequate for all general field determinations.

Prerequisites: Mineralogy 1a and 1b, and Geology 3a.

Required in I. and II.

Junior year, second semester, one hour lecture and three hours' laboratory per week. Credit two and one-half hours.

Text: Kemp, *Handbook of Rocks.*

6b. C. E. GEOLOGY. *Laboratory.* (Eggleston)

Laboratory exercises in reading topographic and geologic maps; in the construction of profile and geologic sections and simple geologic maps; and in the interpretation of significant textures and structures in rocks. This course is the first half of 4b.

Prerequisites: Geology 3a.

Required in III.

Junior year, second semester, six hours per week for the first half of the semester. Credit one and one-half hours.

7a. GEOLOGY OF THE UNITED STATES. *Lectures.* (Eggleston)

The physiography, stratigraphy, economic products, and geologic structure and history of the chief physical divisions of the United States are summarized in the lectures. Written summaries of folios of the United States Geological Survey are required weekly of each student.

Prerequisites: Geology 3b, 4b, and 5a.

Senior year, first semester, three hours per week. Credit three hours.

References: Powell et al., *Physiography of the United States.*
Chamberlain and Salisbury, *Geology, Vols. II. and III.*
Publications of the United States and various State geological surveys.

9a. ECONOMIC GEOLOGY. *Lectures.* (Cox)

A study of the origin, occurrence, and distribution of the metallic ores. Various type deposits of the world are considered, special attention being given to those of the United States. Written reports are required for each district studied; reference always being made to the original reports, thus familiarizing the student with the various technical publications and their usage. The ores of the following metals are considered: zinc, lead, copper, gold, sil-

ver, nickel, cobalt, iron, manganese, tin, mercury, tungsten, platinum, and aluminum. Trips to local points of interest.

Prerequisites: Geology 3b, 4b, and 5a.

Senior year, first semester, five hours per week. Credit five hours.

Text: No text required. Reference largely to reports by the United States geological surveys.

9b. ECONOMIC GEOLOGY. *Lectures.* (Cox)

A study of the origin, occurrence, and distribution of the economic deposits of the non-metals. Reference is made to those technical reports which describe the most important deposits, and a written summary is required for each district studied. The subjects covered are as follows: coal, oil and gas, clays, cements, gypsum, salt, sulphur, sulphides, building stone, abrasives, gems, soils, and fertilizers. Trips to local points of interest.

Prerequisites: Geology 3b, 4b, and 5a.

Senior year, second semester, three hours per week. Credit three hours.

Text: No text required. Reference largely to reports of the United States and State geological surveys.

11a. PETROGRAPHY. *Lectures and Laboratory.* (Cox, McNutt)

The semester is devoted to the study of optics as applied to the determination of minerals by the polarizing microscope, the identification of minerals in thin sections, and the grinding of rock and mineral thin sections.

Prerequisites: Geology 3b, 4b, and 5a, and Physics 3a and 4a.

Senior year, first semester, three hours' lecture and nine hours' laboratory per week. Credit seven and one-half hours.

Text: Luquer, *Minerals in Rock Sections.*

11b. PETROGRAPHY. *Lectures and Laboratory.* (Cox, McNutt)

A study of nomenclature, relations, and alterations of rocks, together with the petrographic analysis and the recalculation of the chemical analysis of rocks.

Prerequisite: Geology 11a.

Senior year, second semester, three hours' lecture and six hours' laboratory per week. Credit six hours.

Texts: Kemp, *Handbook of Rocks*, with one of the following:
Iddings, *Rock Minerals.*
Winchell, *Elements of Optical Mineralogy.*
Johannson, *Determination of Rock-Forming Minerals.*

13b. STRUCTURAL GEOLOGY. *Lectures.* (Cox)

An advanced course in the study of rock deformation, including a review of the theories of the origin of the earth; a discussion of the zones of rock fracture and rock flowage; a classification and discussion of cleavage, joints, faults, folds, autoclastic rocks, conglomerates, and pseudo-conglomerates; and a consideration of mountain building forces, together with the horizontal and vertical depth affected, with application to special districts.

Prerequisites: Geology 3b, 4b, and 5a.

Senior year, second semester, three hours per week. Credit three hours.

14a. FIELD GEOLOGY. *Field Work.* (Cox)

The course consists of both field and laboratory work, the two being varied to suit the weather. The field work consists of the making of topographic and geologic maps, with suitable sections and reports, of assigned areas. The laboratory work includes the making of sections and maps and the final drafting of the field work.

Prerequisites: Geology 3b, 4b, and 5a, and Civil Engineering 4.

Senior year, first semester, six hours per week. Credit three hours.

15b. GEOLOGY CONFERENCE. (Cox)

The conference consists of a discussion by the students and instructors of geologic problems and literature, each student being assigned certain work upon which he must report to the class.

Prerequisite: Geology 9a.

Senior year, second semester, one hour per week. Credit one hour.

MATHEMATICS.

PROFESSOR DEAN, ASSOCIATE PROFESSOR GARRETT.

While the utility of mathematical study as a mental discipline is duly recognized, the ultimate intention of the student is kept in mind, and the matter and methods of the courses are adjusted, as nearly as possible, to meet the demands of subsequent studies and professional practice.

Courses.

1a. COLLEGE ALGEBRA. *Lectures.* (Dean, Garrett)

Theory of limits, logarithms, progressions, binominal theorem, undetermined coefficients, series and solution of higher equations. Special attention is paid to graphical solutions and practical applications.

Prerequisites: Entrance requirements.

Required in I., II., III., and IV.

Freshman year, five hours per week, first twelve weeks. Credit three hours.

Text: Hall and Knight, *College Algebra.*

3a. PLANE TRIGONOMETRY. *Lectures.* (Dean, Garrett)

Solution of plane triangles, reduction and transformation of trigonometric expressions, solution of trigonometric equations.

Prerequisite: Mathematics 1a.

Required in I., II., III., and IV.

Freshman year, remainder of first semester after 1a. Credit two hours.

Text: Taylor and Puryear, *Trigonometry.*

5b. SPHERICAL TRIGONOMETRY. *Lectures.* (Dean, Garrett)

Continuation of Mathematics 3a, taking up more difficult parts of analytical trigonometry, solution of spherical triangles, and simpler problems of spherical astronomy.

Prerequisite: Mathematics 3a.

Required in I., II., III., and IV.

Freshman year, second semester, first five weeks, five hours per week. Credit two hours.

Text: Taylor and Puryear, *Trigonometry.*

7b. ANALYTICAL GEOMETRY. *Lectures.* (Garrett)

The object of this course is to familiarize the student with methods rather than with any particular set of curves. Special attention, however, is given to those forms of the equations of the conic sections which occur in technical literature.

Prerequisite: Mathematics 5b.

Required in I., II., III., and IV.

Freshman year, remainder of second semester after Mathematics 5b, five hours per week. Credit three hours.

Text: Ashton, *Analytical Geometry.*

9a. DIFFERENTIAL CALCULUS. *Lectures.* (Dean)

The student is thoroughly drilled in the derivation of formula, and the application of derivatives in the solution of problems in maxima and minima, in curve tracing, velocity and acceleration, expansion of functions.

Prerequisite: Mathematics 7b.

Required in I., II., and III.

Sophomore year, first twelve weeks of first semester, four hours per week. Credit three hours.

Text: Granville, *Calculus.*

11a, 11b. INTEGRAL CALCULUS. *Lectures.* (Dean)

The student is drilled in the integration of forms occurring in mechanics and physics, in evaluating areas, moments, moments of inertia, in finding centers of gravity, center of stress, and in the derivation and application of fundamental formulae of hydrostatics and hydraulics.

Prerequisite: Mathematics 9a.

Required in I., II., and III.

Sophomore year, five hours per week, after 9a, and first six weeks of second semester. Credit two hours on each semester.

Text: Granville, *Calculus.*

13b. DIFFERENTIAL EQUATIONS. (Dean)

Integrable forms of the differential equations of mechanics and physics, applications of partial differentiation and partial integration, theory of attraction, dynamics of a particle, and thermodynamics of perfect gases.

Prerequisites: Mathematics 11a and 11b.

Required in I., II., and III.

Sophomore year, second semester, five hours per week. Credit three hours.

Texts: Cohen, *Differential Equations.*
Dean, *Manuscript Notes.*

15a. STATICS. *Lectures.* (Garrett)

It is the aim in this course to train the student to apply the principles of statics to practical rather than theoretical problems. In the drafting room graphical methods are developed and applied in the determination of stresses in simple engineering structures.

Prerequisites: Mathematics 11a and 11b.

Required in I., II., and III.

Junior year, four hours' lectures per week, first half of semester; laboratory, one period per week during first semester. Credit three and one-half hours.

Text: Maurer, *Technical Mechanics.*
Notes by instructor.

17a. MECHANICS OF MATERIALS. *Lectures.* (Garrett)

The more elementary and fundamental parts of the subject are here taken up. The student is given a thorough drill in the application of principles to simple problems of design and in the use of standard hand-books.

Prerequisite: Mathematics 15a.

Required in I., II., and III.

Junior year, second half first semester, four hours per week. Credit two hours.

Text: Merriman, *Mechanics of Materials.*

19b. MECHANICS OF MATERIALS. *Lectures.* (Garrett)

This course begins with the study of the elastic curve and includes the more advanced topics. As in the preceding course a thorough drill in the practical application of the principles developed forms an important part of the work.

Prerequisite: Mathematics 17a.

Required in I., II., and III.

Junior year, first half second semester, four hours per week. Credit two hours.

Text: Merriman, *Mechanics of Materials.*

20b. MATERIALS LABORATORY. *Laboratory.* (Garrett)

This course is to be taken with Mathematics 19b. A study of the properties and standard tests of a variety of structural materials including metals, timber, brick, stone, cement, and concrete.

Prerequisite: Mathematics 17a.

Required in I., II., and III.

Junior year, second semester, three hours per week. Credit one and one-half hours.

21b. DYNAMICS. *Lectures.* (Garrett)

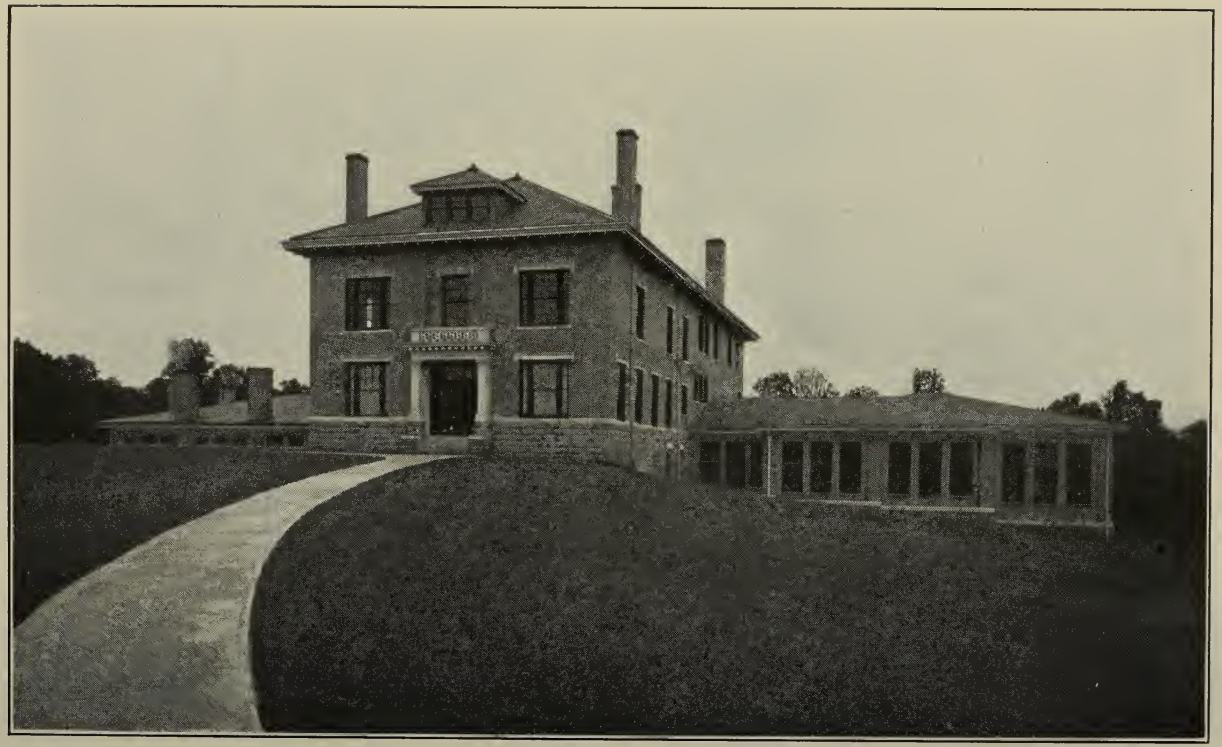
This course includes kinematics and kinetics with technical applications.

Prerequisite: Mathematics 15a.

Required in I., II., and III.

Junior year, second half of second semester, four hours per week. Credit two hours.

Text: Maurer, *Technical Mechanics.*



METALLURGY AND ORE DRESSING BUILDING

METALLURGY AND ORE DRESSING.

Professor Copeland, Mr. Dudley, Mr. Mann, Mr. Illinski.

Equipment.

The assay laboratory has a floor space of forty-eight hundred square feet. In the main room are twenty coal-fired, double-muffle assay furnaces, twelve gasoline-fired muffle furnaces, and ten coke-fired furnaces. Desks containing lockers, pulp balances, and fluxes are arranged close to the furnaces.

A room 16 by 16 feet, separated from the furnace laboratory by glass partitions, is used for parting. There are in this room the necessary hot plates, acid jars, and annealing muffles. The desks in this laboratory are topped with white tiling.

The balance room is 20 by 20 feet and is lighted only from the north. It is easily kept at constant temperature. There are eleven balances suitable for weighing gold. A number of these balances have the multiple-rider attachment.

For chemical work in connection with metallurgy, there is a well-lighted room having fifty-six lockers and fifty-six desks. Each desk is provided with gas, compressed air, and water. There is in the room ample hood space; in fact, the laboratory has everything necessary for general chemical work.

There is, in the main furnace room, a circular water-jacket blast furnace, 20 inches in diameter at the tuyeres, and 7-foot smelting column. This furnace is used for lead and copper smelting. For roasting ores a hand reverberatory furnace, with a hearth 4½ by 9 feet, is provided. This laboratory contains also an experimental pot roaster, an experimental zinc distilling furnace, three La Chatlier thermo-electric pyrometers, and a Wänner optical pyrometer.

A stock room, containing chemicals, clay goods, glassware, and other supplies, serves all the laboratories. The ore-sample room is especially well equipped. It contains more than 1,000 samples of ore of varied classes. Each sample is stored away in paper sacks, all ready for issuing to the students. Each sample has been prepared and carefully assayed. Enough of each lot of ore has been prepared to give 200 to 300 samples of the same lot. The sample room, therefore, contains more than 1,000 different samples of ore, each sample being divided into 200 or more smaller samples, each of the smaller samples being ready for immediate issue.

Throughout the meallurgical and ore-dressing laboratories care has been taken that each furnace, each piece of apparatus, should be so arranged as to be fitted best for that testing work which must be so great a part of the student's work. In all the laboratory work, in addition to demonstrating the theories and principles explained in the class room, the attempt is made to give the man ability to do a day's work and to teach him to use both his head and his hands.

The main floor of the new ore-dressing laboratory occupies a space of forty-eight hundred square feet and a mezzanine floor provides an additional space of thirteen hundred square feet. The equipment of the laboratory is as follows: The crushing and sampling department contains a gyratory breaker, a Dodge breaker, a pair of 9-in. by 12-in. rolls, two plane shaking screens, two Vezin samplers, two bucket elevators, three belt conveyors, and six ore storage bins, each equipped with an automatic feeder. For fine crushing and amalgamation tests are provided a three-stamp mill, with amalgamated plates, and a 3½-foot Huntington mill.

Ores are prepared for concentration by the following series of machines: Three trommel screens, a duplex Callow traveling belt screen, a Richards pulsator classifier, a four-spigot Richards vortex classifier, a three-spigot cone classifier, a small Tamarack classifier, and four Callow settling cones.

Methods of concentrating coarsely crushed ores are illustrated by three five-cell differential motion Harz jigs, a Richards pulsator jig, and a small model of the Hancock jig. Sands are treated on two laboratory-size Wilfley tables, one laboratory Card table, and one laboratory James table. A four-foot Frue vanner and a five-foot Sperry slimer are provided for the treatment of fine materials.

Two direct-connected motor-driven centrifugal sand pumps are used for elevating finely crushed ore to the screening and classification system.

The sample finishing room contains a small Blake crusher, a disc grinder, a coffee mill, a pair of rolls, a number of bucking boards and mullers, a laboratory tube mill, and an electric sample dryer.

The cyanide unit contains a laboratory leaching plant with all necessary tanks, a 16-in. Hendryx clay agitator, a 14-in. Hendryx combination agitator and filter, and a six-leaf 12-in. by 12-in. filter press.

Ores suited to magnetic concentration are treated on a Knowles magnetic separator, and for the preparation of such ores a cylindrical dryer and roaster, together with a plane impact screen for dry sizing, is provided.

Throughout the mill, wherever possible, the practice of driving each machine with an individual motor has been followed.

It is recognized that a school cannot give students, in the brief time at its disposal, that skill which comes from long practice, but it is the aim to give such training in the fundamental principles and their application that students may become useful immediately on their entrance into the actual practice of their chosen profession. All metallurgical courses are accompanied by graded metallurgical problems.

An important feature of the instruction is experimental investigation in the metallurgical treatment of various ores.

Courses.

1b. FIRE ASSAYING. *Lectures.* (Mann)

This course deals with the theory of fire assaying as practiced in the laboratory. The points discussed are outlined under Metallurgy 2b.

Prerequisites: Chemistry 1a and 2a.

Required in I. and II.

Junior year, second semester, two hours per week. Credit two hours.

Texts: Lodge, *Notes on Assaying.*
Fulton, *Assaying.*

2b. FIRE ASSAYING. *Laboratory.* (Mann)

This work includes the assay, by scorification and crucible methods, of ores from the various districts of the United States. Copper ores, copper mattes, and copper bullions are assayed by fire and by the combination method. Lead ores and furnace products are assayed for lead and for gold and silver. Assays of cyanide solutions, of zinc-box residues, of silver bullion, of gold bullion, of lead bullion, and of silver-mill precipitate, are included in this course. During the course the student has practice with coal furnaces, coke furnaces, and gasoline furnaces. Besides doing the ordinary work of assaying, the student studies the losses occurring. He learns the effects of different schemes of firing the furnaces by making analyses of the flue gases and by pyrometric measurements. The laboratory is so arranged that even with large classes a student is not hampered by other students and he learns to handle a large amount of work with the best utilization of his time.

Prerequisites: Chemistry 1a and 2a. To be preceded by Geology and Mineralogy 1a.

Required in I. and II.

Junior year, second semester, nine hours per week. Credit four and one-half hours.

Texts: Lodge, *Notes on Assaying.*
Fulton, *Assaying.*

3b. GENERAL METALLURGY AND METALLURGY OF IRON. *Lectures.* (Copeland)

General Metallurgy. This course is an introduction for the other metallurgical courses and the work covered is shown by the following headings: The chemical equation from the standpoint of the metallurgist; methods of combustion; the temperature obtainable by any system of combustion, and the effect thereon of certain variables; the methods of measuring high temperatures, including the use of the more common forms of pyrometer; means of supplying oxygen for combustion, including the principles of stack design; metallurgical fuels and methods of using them, including the coals, oils, natural gas, coke, charcoal, and producer gas; measuring the heat-giving power of fuels; refractory materials and their uses; types of furnaces and the reasoning in their design; a general study of some typical metallurgical operations to bring out the many principles that have been taught in the earlier courses that are of wide application in metallurgy; a study of the transfer of heat through refractory materials. In this course much attention is given to methods of attacking the simpler arithmetical problems of metallurgy.

Metallurgy of Iron and Steel. The following headings show the work taken up in this course: The properties of iron, its alloys and compounds; definitions for the various kinds of iron; the ores of iron and the principles underlying their valuation and sale; the preparation of iron ores for the blast-furnace; the iron blast-furnace, its construction and operation; the manufacture of pig iron; the properties of pig iron and the factors on which these properties depend; the calculation of furnace charges; the chemistry of the iron blast-furnace; the metallurgical operation of the iron blast-furnace; the manufacture of steel by basic and acid bessemer, basic and acid open-hearth, and crucible methods; the manufacture of wrought iron; the constitution and structure of iron and steel from the modern standpoint of metallography; the heat and mechanical treatments of iron and steel; alloy steels are considered only in a brief manner.

Prerequisites: Chemistry 3b and 4b, Geology and Mineralogy 1b.

Required in I., II., and III.

Junior year, second semester, three hours a week. Credit three hours.

Texts: Stoughton, *Metallurgy of Iron and Steel.*
Sauveur, *Metallography of Iron and Steel.*
Fulton, *Principles of Metallurgy.*
Richards, *Metallurgical Calculations.*

5a. METALLURGY OF THE NON-FERROUS METALS. *Lectures.* (Copeland)

This course includes a study of the metallurgy of lead, copper, zinc, gold, silver, tin, antimony, and aluminum. The greater part of the time is spent on the metallurgy of lead, copper, zinc, gold, and silver.

METALLURGY OF LEAD. The course in the metallurgy of lead includes work along the following general lines: The properties and uses of lead, its alloys, and compounds. The ores of lead and methods and principles of their sale. Principles and practice of sampling ores and products. The general principles made use of in the winning of lead from its ores. The treatment of lead ores in the reverberatory smelting furnace. The winning of lead from its ores by smelting in the ore hearth or Scotch hearth, considerable attention being paid to this method on account of its importance with the ores of the Mississippi Valley. The roasting of lead ores and the strides that have recently been made in this important preliminary to the lead blast-furnace. The winning of ores in the lead blast-furnace. This heading is, of course, an important one in the subject and under it are taken up the blast-furnace plant, the chemistry of the blast-furnace, the calculation of furnace charges, the calculation of costs of smelting, the handling of products particularly the smoke or fume. The desilverization of base bullion by means of the Parkes, Pattinson, and cupellation processes, as well as by the Betts process. Throughout this course, as well as the other courses in this department, the work is accompanied by problems which bring out the ideas that the class-room work considers.

Texts: Hofman, *Metallury of Lead.*
Collins, *Metallurgy of Lead.*
The Articles Appearing in the Technical Journals.

METALLURGY OF COPPER. The metallurgy of copper is considered along the following general lines: The properties and uses of copper, its compounds, and its alloys. The markets for copper and its ores and the principles underlying their sale and price. The ores of copper. The smelting of roasted and oxidized ores of copper to black copper is touched only briefly. The roasting of copper ores as a preliminary to blast-furnace and reverberatory smelting. The handling of the smoke from copper furnaces to save the values contained therein and to remove from these gases their injurious constituents. The smelting of roasted ores to matte in the reverberatory furnace. The smelting of roasted ore to matte in the blast-furnace either with or without the attempt to volatilize a considerable portion of the sulphur. The smelting of raw massive sulphides to matte in the blast-furnace, or pyrite smelting. The converting of copper matte to blister copper in the basic and in the acid converter.

The furnace refining of copper. The production of copper from matte by the various roast-reaction or roast-smelting methods. The electrolytic refining of copper.

Texts: Peters, *Practice of Copper Smelting.*
Peters, *Principles of Copper Smelting.*
References in the Technical Journals.

Metallurgy of Zinc. The metallurgy of zinc is considered under the following headings: The properties and uses of zinc, its alloys, and its compounds. The ores of zinc and the methods and principles underlying their sale. The roasting of zinc ores with a brief study of the use of zinc ores as a source of sulphuric acid. The distillation of zinc ores and furnaces suited for this purpose. The factors on which the success of the distillation depends. The manufacture of retorts and condensers. The laws of condensation of vapor to liquid and their application to the condensation of zinc vapors. The products of zinc smelting, and the methods of handling and treating these products. The cost of smelting zinc ores figured on the basis of a number of typical ores. The refining of spelter. The markets for spelter and the various brands of spelter. Special schemes other than the ordinary methods that have been used or proposed for use in the winning of zinc from its ores. The manufacture of zinc oxide pigment. Throughout the course problems are given to illustrate the ideas set forth in the class.

Text: Ingalls, *Zinc.*

Metallurgy of Gold and Silver. The metallurgy of gold. The work in this course includes lectures and recitations along the following general lines: The properties of gold, gold alloys and the compounds of gold. The winning of gold from placer ground by dredging and hydraulicing, including methods of investigating the value of placers. The chlorination and bromination of gold ores are considered more in the light of the historic value of these processes than for their present importance as schemes of gold extraction. The amalgamation methods for silver and gold ores are taken up in detail in the course in ore dressing.

The metallurgy of silver is considered as suggested by the following headings: The properties of silver, of its alloys, and of the compounds of silver. The winning of silver from its ores by the various leaching schemes that were formerly of greater importance than at present. These schemes include the Augustin process, the Ziervogel or Argo process, the various methods of hyposulphite leaching; they are considered only briefly. The greater part of the time of the course in gold and silver is devoted to the study of the cyanide process which is considered in considerable detail. The parting of gold and silver by the various acid and electrolytic schemes. The winning of gold and silver from their ores by the

BLAST-FURNACE

various smelting schemes is considered under the head of the metallurgy of lead and copper.

Texts: Rose, *Metallurgy of Gold.*
Collins, *Metallurgy of Silver.*
Julian and Smart, *Cyaniding.*
Clennell, *Cyaniding.*
The Technical Journals.

Prerequisites: Metallurgy 3b and Chemistry 6b.

Senior year, first semester, four hours per week. Credit four hours.

5b. METALLURGY OF THE NON-FERROUS METALS. *Lectures.* (Copeland)

This is a continuation of Metallurgy 5a.

Prerequisites: Metallurgy 3b and Chemistry 6b.

Senior year, second semester, four hours per week. Credit four hours.

6a. METALLURGY. *Laboratory.* (Copeland, Mann, Illinski)

This course covers the testing of ores for process treatment. Ores are tested by cyaniding, chlorination, amalgamation, lixivation, concentration, and by combination methods. With aid of smelter schedules, the smelting costs are calculated and the net dollars and cents returns are balanced against the best results by any method. or combination of methods, worked out in the laboratory. The endeavor is made, not only to teach metallurgical principles in the laboratory, but also to bring home to the student the great effect that freight rates and such other factors have on the treatment which an ore should receive. Experiments are made in the reverberatory and "pot" roasting of ores, and on blast-furnace smelting of ores. Furnace heat equations are made by each student from data collected by himself.

Prerequisites: Metallurgy 1b, 2b, and 3b.

Senior year, first semester, four hours per week. Credit 1.5 hours.

Text: Howe, *Metallurgy Laboratory Experiments.*

8a. METALLURGY. *Laboratory.* (Copeland, Mann)

A more extended course than 6a. Planned for students specializing in metallurgy.

Prerequisites: As in 6a.

Senior year, first semester, seven hours per week. Credit three hours. Recommended for II.

Text: As in 6a.

9a. ELECTRO-METALLURGY. *Lectures.* (Copeland)

Lectures are given covering the electro-metallurgical processes that are in use. Efficiency and engineering calculations based on these processes are given.

Prerequisites: Metallurgy 3b, Physics 1b and 3a, Chemistry 9a, 10a, and 7a.

Senior year, second semester, five hours per week. Credit five hours.

10a. ELECTRO-METALLURGY. *Laboratory.*
(Copeland, Illinski)

This course gives a study of the principles of electro-metallurgy from the standpoint of experiments actually performed. Tests are made on the electrolytic refining of copper and of lead bullion. Experiments are performed and calculations as to efficiency are made on electric smelting.

Prerequisites: Physics 1b and 3a, Chemistry 9a, 10a, and 7a. Accompanied by Metallurgy 9b.

Senior year, second semester, six hours per week. Credit three hours.

13a. METALLURGY PROBLEMS. (Copeland)

These problems aim to cover the common ones that the metallurgist meets in practice.

Prerequisite: Metallurgy 3b. To accompany Metallurgy 5a.

Senior year, first semester, one hour per week. Credit one hour.

Text: Richards, *Metallurgical Calculations.*

15b. METALLURGICAL MEMOIRS. *Lectures.* (Mann)

The student in the Metallurgy Curriculum is required to do a considerable amount of technical reading in German and English. Carefully prepared abstracts of valuable current articles are presented and read by each student.

Prerequisite: Metallurgy 5a.

Senior year, second semester, one hour per week. Credit one hour.

17a. METALLURGY CONFERENCE. *Lectures.* (Copeland)

The lectures cover the work being given at the time in the laboratory in Metallurgy 6a.

Prerequisite: Metallurgy 3b. To accompany Metallurgy 6a.

Senior year, first semester, one hour per week. Credit one hour.

19a. METALLURGY PLANT. *Lectures.* (Copeland)

The arrangements of various metallurgical works are studied. The advantages and disadvantages of different equipments are given.

Prerequisites: Metallurgy 3b, 5a, and 5b.

Graduate course, first semester, two hours per week. Credit two hours.

20a. METALLURGY PLANT DESIGN. *Laboratory.* (Copeland)

This is a drafting-room course, and the student is given problems to solve in detail, covering a part of the class-room discussions. Each student is required to submit complete drawings, specifications, and estimations of cost.

Prerequisites: Shop Practice and Drawing 2b, Metallurgy 3b, 5a, and 5b.

Graduate course, first semester, six hours per week. Credit three hours.

21b. CYANIDING. *Lectures.* (Mann)

This course teaches the principles and practice of cyaniding. The student keeps up with the progress in the art. Attention is given in all the work to the cost of operation and to the schemes used and proposed for lessening the cost. A detailed study is made of the types of filter presses, crushing machinery, and other devices used in cyanide mills. Cyaniding is compared with other possible methods of treatment.

Prerequisites: Metallurgy 1b, 2b, and 3b.

Graduate course, first semester, four hours per week. Credit four hours.

22b. CYANIDE LABORATORY. (Mann)

The student in this course has an opportunity to test in the laboratory the methods discussed in the class room. The work is not routine, but the experiments are arranged to bring out a point under discussion, or to solve, if possible, the problems occurring at the time in the class room.

Prerequisites: Metallurgy 1b, 2b, and 3b. To accompany Metallurgy 21a.

Graduate course, first semester, six hours per week. Credit three hours.

23b. ORE SUPPLY. *Lectures.* (Copeland)

This course is intended to bring out the important subject of ore, flux, and fuel supplies. The subject is studied from a combined commercial and technical standpoint. The problems of valuing

fluxes and fuels, of mixing ores so that the mixture shall command the lowest treatment rate, and of preparing, from the reduction works' standpoint, treatment charges for different classes of ores, are studied.

Prerequisites: Metallurgy 5a and 5b.

Graduate course, second semester, two hours per week. Credit two hours.

25a. METALLURGICAL RESEARCH. *Laboratory, Reading, and Conferences.* (Mann)

Each graduate student elects a subject for special study. It is recommended that the work be along a different line from the subject chosen for thesis. The course consists principally of assigned reading, together with conferences with the professor on the matter read. The laboratories are always open for the solving of any problem that may arise.

Prerequisites: Metallurgy 5a and 5b.

Graduate course, first semester, five hours per week. Credit five hours.

25b. METALLURGICAL RESEARCH. *Laboratory, Reading, and Conferences.* (Mann)

This course is a continuation of Metallurgy 25a.

Prerequisite: Metallurgy 25a.

Graduate course, second semester, five hours per week. Credit five hours.

27b. ADVANCED METALLURGICAL PROBLEMS. *Lectures.* (Copeland)

This course has reference to the designing and proportioning of various types of furnaces for special duties and conditions.

Prerequisite: Metallurgy 13a.

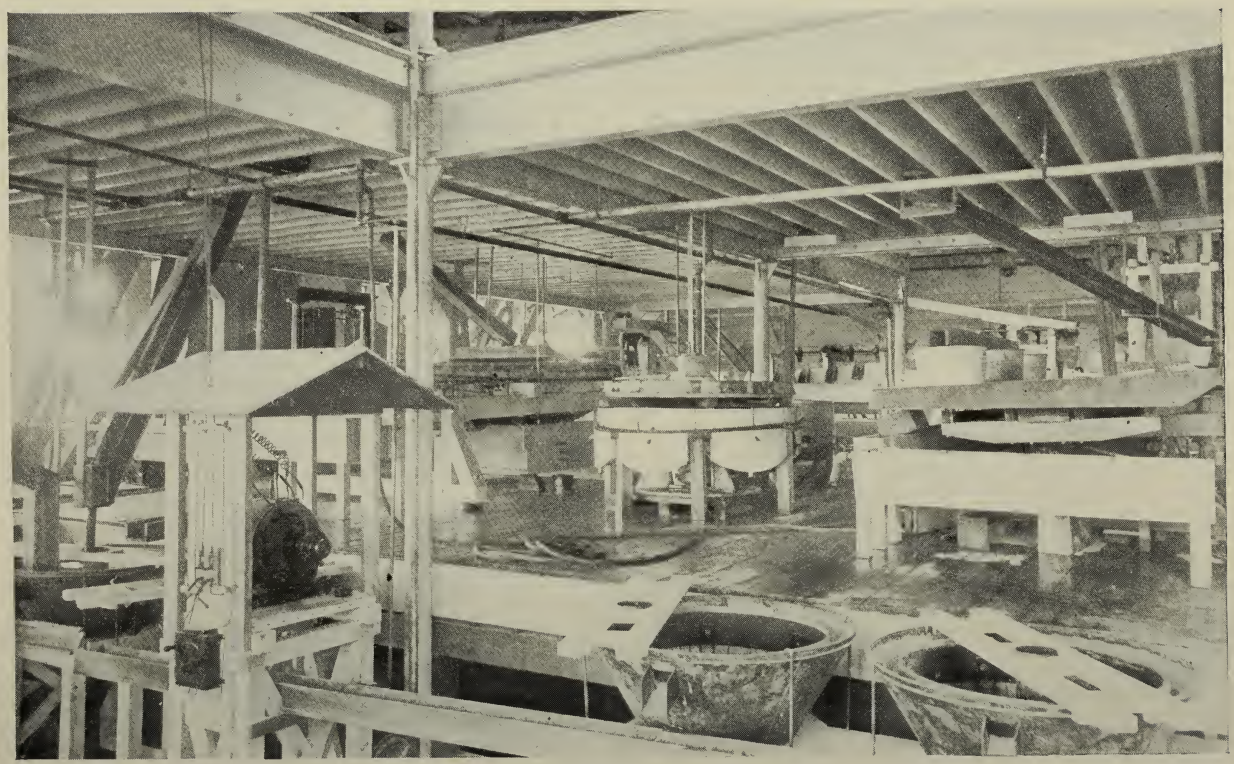
Graduate course, second semester, two hours per week. Credit two hours.

29a. ALLOYS AND METALLOGRAPHY. *Lectures.* (Copeland)

These lectures deal with the theoretical and practical considerations that influence the structure and properties of alloys of different types.

Prerequisites: Chemistry 7a, Metallurgy 3b.

Senior year, first semester, two hours per week. Credit two hours.



ORE DRESSING LABORATORY

30a. ALLOYS AND METALLOGRAPHY. *Laboratory.*
(Copeland, Dudley, Illinski)

This laboratory course is given in connection with the lectures, and deals chiefly with the micro-structure of iron and steel.

Prerequisites: Chemistry 7a, Metallurgy 3b.

Senior year, first semester, three hours per week. Credit 1.5 hours.

31b. ELEMENTS OF ORE DRESSING. *Lectures.* (Mann)

In this course the principles of all common ore-dressing processes are briefly discussed. The various machines used for crushing, classification, and concentration of ores are described. Especial attention is given to those processes and mill schemes which the student has opportunity to see while on the Junior trip.

Prerequisites: Mathematics 15a, and Mineralogy and Geology 1b.

Required in I. and II.

Junior year, second semester, two hours per week. Credit two hours.

Text: Richards, *Text-Book of Ore Dressing.*

33a. ORE DRESSING. *Lectures.* (Mann)

In this course the principles of mechanical ore treatment are discussed in detail. The construction and theory of machines are presented in lectures, supplemented by a full equipment of models, which show the design of all common ore-dressing appliances. The latter part of the course deals with the management of mills and with the adaptation of processes to the successful treatment of various ores.

Prerequisite: Metallurgy 31b.

Senior year, first semester, four hours per week. Credit four hours.

Text: Richards, *Text-Book of Ore Dressing.*

33b. ORE DRESSING. *Lectures.* (Mann)

This course is a continuation of Metallurgy 33a.

Prerequisite: Metallurgy 33a.

Senior year, second semester, four hours per week. Credit four hours.

Text: Richards, *Text-Book of Ore Dressing.*

34a. ORE DRESSING PROBLEMS. *Laboratory.*
(Copeland, Mann)

In this course advanced work is given in connection with the design of plants and machinery for the treatment of ores. The

course includes the determination of a practical process for treating a given ore, and the design of a mill for utilizing this process.

Prerequisites: Metallurgy 1b, 2b, and 31b, Shop Practice and Drawing 2b. To be accompanied by Metallurgy 33a.

Senior year, first semester, three hours per week. Credit 1.5 hours.

36b. ORE DRESSING LABORATORY.

(Copeland, Mann, Illinski)

The student becomes familiar with the operation and care of milling machinery by actual laboratory experience. All types and classes of machines are available to illustrate principles and practice as presented in the lecture work. The laboratory is so arranged that a number of mill schemes may be utilized and processes for treating a particular ore can be determined from mill tests on large quantities of the ore.

Prerequisites: Metallurgy 1b, 2b, and 33a. To be accompanied by Metallurgy 33b.

Senior year, second semester, six hours per week. Credit three hours.

MINING.

Professor Forbes and Director Young.

The surveying equipment already referred to in Civil Engineering is used for mine surveying. The School of Mines has several thousand drawings and blue-prints of mining machinery and mine plants which are used in connection with the work in mining and mine management. There are also in the library a large number of lantern slides and photographs illustrating mining practice in the United States.

Besides the well-equipped machine and blacksmith shops, the steam engines, air-compressors, pumps, and electrical equipment provided by the School for use in various laboratory courses, and which are available for the study of mining machinery, the department has the following exclusive mining equipment:

For rock-drilling: One Ingersoll-Rand 2¼-in., arc-tappet valve, piston drill; one Sullivan 2¼-in., differential-valve, piston drill; one Wood 2¼-in., spool-valve, piston drill; one Sergeant 2½-in., tappet-valve, piston drill; one water Leyner, Number 7, hammer-drill; one Cleveland, valve type, hand hammer-drill; one Murphy, valveless type, hand hammer-drill, with air-feed; one Hardsocg, valveless type, hand hammer-drill, with air-feed; one Leyner drill sharpener; one double-screw column with arm; one single-screw column; two tripods with weights; drill steel, air hose, and other accessories.

For mine rescue-work: One Draeger oxygen helmet, 2-hour type, 1911; one Draeger pulmotor; one Draeger oxygen pump; one Westfalia oxygen helmet, 2-hour type; one Fleuss self-contained breathing apparatus, 2-hour type; electric lamps and nine different types of safety lamps; and Red-Cross First Aid Outfits.

1b. MINING. *Lectures.* (Forbes)

This course outlines the principles on which the science of Mining Engineering is founded, and is designed to introduce the student to fundamentals which will enable him to appreciate the application of the other studies of the Freshman and Sophomore years.

Prerequisites: Entrance requirements.

Required in I., II., III., and IV.

Freshman year, second semester, two hours per week. Credit two hours.

3a. MINING. *Lectures.* (Forbes)

This course includes lectures on prospecting, drilling, blasting, supporting excavations, tunneling, and shaft sinking. The various tools and appliances used in mining operations are described, and a review of the methods of mine timbering is included in the course.

Prerequisite: Mining 1b.

Required in I., II., and III.

Sophomore year, first semester, three hours per week. Credit three hours.

5b. MINE SURVEYING. *Lectures.* (Forbes)

The theory and the practice of the surveying of mineral lands and mines are presented by lectures. Many problems are introduced and the student is trained in various calculations, including the reduction of notes of underground surveys requiring the auxiliary telescope, volumes of stopes, mineral acreage, intersection of veins, underground connections, and the general problems in the determination of the location of mine openings.

Prerequisite: Civil Engineering 2a.

Required in I., II., and III.

Sophomore year, second semester, two hours per week. Credit two hours.

6. MINE SURVEYING. *Laboratory.* (Forbes)

A mine surveying trip to Joplin or other mining districts is a required part of the work of the Sophomore year. In this course the student is given an opportunity to do mine surveying under actual mining conditions. The course lasts from ten days to two weeks, depending on the ability of the student, who is required to make a correct survey and map of a certain part of a mine. Credit 3 units.

Prerequisite: Mining 5b.

8. JUNIOR TRIP.

At the end of the school year the members of the Junior class make a three weeks' trip to the mining districts of Colorado and Utah. The purpose of the trip is to give an opportunity for the study of the methods of mining and concentration of ores in the districts visited, together with work in geology.

Prerequisites: Mining 5b, Geology 3b, and Metallurgy 31b.

Required in I. and II.

Junior year, Summer session. Credit 4.5 hours.

10. PRACTICAL MINING.

In order to stimulate interest in practical mining, the mining

department offers the following plan by which credit may be obtained for such work.

The student must spend at least three weeks in the study of practical mining operations, at some mine designated by the department, taking notes, making sketches, and observing details of mining operations.

Instead of the above work, the student may obtain employment at any mine of his own selection, which is acceptable to the department, for a period of not less than six weeks, four weeks of which must be spent in underground work. This work will be accepted as a substitute for the above only when accompanied by a satisfactory report, an outline of which will have been given to the student in advance.

Credit may be obtained for the above work by submitting the report on same as a thesis, if approved by the thesis committee, and also some credit may be allowed toward the Senior mining laboratory for equivalent work, at the discretion of the mining department.

All reports on Summer Practical Mining must be presented to the department not later than September 15th.

Prerequisites: Mining 3a and 5b.

No credit will be allowed for Practical Mining unless followed by courses 21a, Mining Conference; and 23b, Mining.

Junior year, Summer session.

11a. MINING LAW. *Lectures.* (Young)

The general principles of mining law are reviewed with discussion of legal decisions in representative cases. The students are given the general principles governing the making of contracts, together with discussion of contracts typical of various mining districts.

Prerequisites: Mining 3a, Geology 3a and 3b.

Senior year, first semester, one hour per week. Credit one hour.

13b. MINE MANAGEMENT. *Lectures.* (Young)

This course is planned to give the student an idea of the principles of management of mining enterprises, and reviews methods of mine organization and mine accounting. Economic problems in connection with mine management are presented. The practice of mine examination and mine reporting is reviewed.

Prerequisites: Mining 5b and 7a.

Senior year, second semester, two hours per week. Credit two hours.

Texts: Rickard, *Economics of Mining.*
Rickard, *Ore Sampling.*

15a. COAL MINING MACHINERY. *Lectures.* (Forbes)

This course includes an outline of the various types of machinery used in mining operations and is planned to familiarize the student with the best designs of machinery in order that he may be able to select the proper machine for the particular condition. The machinery studied includes rock-drills, coal-cutters, mine-hoists, mine-pumps, mine locomotives, wire-rope haulage systems, mine fans, and safety appliances.

Prerequisite: Mining 3a.

Senior year, first semester, two hours per week. Credit two hours.

17a. COAL MINE VENTILATION. *Lectures.* (Forbes)

This course includes a study of the various gases met with in mines, their origin, effects, and detection; the amount of fresh air required for men and animals under varying conditions; natural and artificial means of ventilation; gas and dust explosions and mine rescue work. A large part of the course is devoted to problems in mine ventilation.

Prerequisites: Physics 1b and Mining 3a.

Senior year, first semester, two hours per week. Credit two hours.

18b. FUEL TESTING. *Laboratory.*

In this course the student is required to test the calorific power of different coals by burning them under a boiler or in a gas producer. Analyses of coal tested are made and also tests as to their coking qualities.

Prerequisite: Chemistry 6a.

Senior year, second semester, three hours per week. Credit one and a half hours.

19a. MINING ECONOMICS. *Lectures.* (Young, Forbes)

Various economic problems of interest to mining engineers are studied. The influence of mining in the history of America and especially in United States history is reviewed and the relation of mining to other industries is considered. The organization of the mining industry, the conservation of the mineral resources, and various problems in economics, including mining labor, wages, capital, taxation, profit-sharing, and employers' liability are presented by lectures and assigned reading.

Prerequisites: Mining 13b, Geology 9a.

Graduate course, first semester, one hour per week. Credit one hour.

20a, 20b. MINE PLANT DESIGN. *Laboratory.* (Forbes)

This is a drafting-room course and is supplementary to all the previous mining courses. Each student is required to prepare complete drawings for the equipment of a given mine. Bills of material, specifications, and complete estimates are submitted.

Prerequisites: Mining 13b and Civil Engineering 15a.

Graduate course, first and second semesters, three hours per week. Credit three hours.

21a. MINING CONFERENCE. (Forbes, Young)

In this course the notes and observations made in Mining 10 are discussed and compared. Mining methods in general are studied chiefly by reference to articles in the current technical press.

Prerequisite: Mining 10.

Senior year, first semester, one hour per week. Credit one hour.

22a. MINING LABORATORY. (Forbes, Bowen)

The work in this course includes shop work and rock drilling, drafting, and mine rescue work.

Shop Work and Rock Drilling.—This work consists of sharpening, hardening and tempering drill-steel, both for hand and machine drilling; practice in single-hand and double-hand drilling; and a practical study of the construction and operation of machine drills.

Mine Rescue Work and First Aid.—It is the purpose of this work to train the student in the construction and use of mine rescue apparatus, including oxygen helmets of various kinds and resuscitating devices. He is required to do a certain amount of work wearing the helmet in a smoke chamber filled with smoke or some unbreathable gas. The study of "First Aid to the Injured" is a part of this course and practical demonstrations of first aid treatment are required of the student.

Prerequisite: Mining 10.

Senior year, first semester, one afternoon per week. Credit one and a half hours.

23b. MINING. *Lectures.* (Forbes)

The study of mine haulage, hoisting, drainage, ventilation, and lighting is included in this course. A study of the mining plant in general is made, including the cost of equipment and operation.

Prerequisite: Mining 21a.

Senior year, second semester, two hours per week. Credit two hours.

PHYSICS.

Professor McRae, Mr. Buerstatte, Mr. Hollister.

Equipment.

The lecture room and laboratories for Physics and Electricity are in Norwood Hall. The lecture room will seat one hundred students and is provided with water, gas, and electric connections for conveniences in lecture demonstrations and experiments.

The physical laboratory is on the ground, or basement, floor. There are two large laboratories, one equipped for general physical measurements in mechanics, sound, and heat, and one equipped for electric measurements. There is a battery room equipped with both primary and secondary batteries connected by wire with the various laboratories and the lecture room; a constant-temperature room with double walls and air space insulation; a commodious dark-room with blackened walls for spectrometric and photometric measurements, and a special laboratory for research work.

The equipment includes a Rowland electro-dynamometer with shunts and resistances; a Leeds & Northrup decade wheatstone bridge; a Queen & Co. postoffice pattern wheatstone bridge; two portable testing sets; various wheatstone bridges and resistance boxes; standards of resistance, inductance and capacity; a Lummer-Brodhun photometer; a Gaertner dividing-engine, with linear and circular attachments; a Threlfall micromanometer; a Duddell thermo galvanometer; various tangent, mirror and D'Arsonval galvanometers; a Parr coal calorimeter; a wireless telegraph demonstration set; a ten-inch induction coil; Crooke's tubes; X-ray tubes; Toepler Holtz machine; a Schmidt & Haensch spectrometer; a Rowland diffraction grating; photographs of Rowland's normal solar spectrum; Crosby, Thompson, and Schaeffer and Budenberg steam and gas engine indicators; Amsler planimeters; tachometers and speed counters; Hays, Peabody, and Schaeffer and Budenberg moisture calorimeters, General Electric Steam flowmeter; various balances; micrometers, calipers, together with apparatus for illustrating the principles of physics.

The dynamo laboratory contains an assortment of direct-current generators and motors, a General Electric double-current generator for direct current and alternating current work, a single and a three-phase generator, an induction motor, a single-phase repulsion motor, a rotary transformer, stationary transformers,

three-phase to two-phase transformers, and a Cooper-Hewitt mercury vapor converter, testing instruments, which include a Weston laboratory standard voltmeter, with multipliers; a Weston laboratory standard milli-voltmeter, with shunts; a Kelvin electrostatic voltmeter; Weston portable direct current ammeters; Weston portable direct current and alternating current voltmeters; Weston, and Thomson portable wattmeters; Thomson alternating current voltmeters; Westinghouse portable polyphase wattmeter; Westinghouse portable voltmeter with transformers; Westinghouse portable ammeters with series transformers; electro-dynamometers; a Grassot fluxmeter; inductance coils, and condensers.

The power plant also is used for experimental purposes, and comprises a strictly modern and thoroughly equipped laboratory. The machinery available for testing purposes includes four 130-h. p. Heine Safety boilers; a 13 by 14 Ball engine direct connected to a 75 kw. 220-volt D. C. Westinghouse generator, a 10 by 12 Ideal engine direct connected to a 50 kw. 220-volt D. C. Westinghouse generator, a 9 by 14 Brownell engine equipped with a rope friction brake, a 5 by 7 Rankin and Davis vertical engine equipped with a prony brake. A 21-h. p. Otto gas engine may be belted to electric generators or used for experimental purposes. The pneumatic equipment includes a Laidlaw-Dunn-Gordon air compressor, a Rand Imperial type air compressor, a 72-inch ventilating fan, a 36-inch ventilating fan, and a 60-inch Buffalo forge blower. There are six pumps of three different patterns, which can be used for power or experimental purposes. The electric generators include, in addition to those mentioned above, a 3½-kw. 120-volt generator, a 15-kw. General Electric 220-volt interpole direct-current generator, a 7½-kw. General Electric direct and alternating-current generator, a 2-kw. three-phase Westinghouse generator, and a 1-kw. Westinghouse single-phase generator.

The switchboard contains a Tirrill voltage-regulator and a Thompson recording watt-hour-meter, in addition to the usual instruments.

The various electrical motors used for power purposes in the shops and laboratories are available for testing in addition to the machinery in the dynamo laboratory. The total electrical equipment includes thirty-five motors, varying in size from ½-h. p. to 35-h. p., with the aggregate rating of 225 h. p.

Courses.

1b. GENERAL PHYSICS. *Lectures.* (McRae)

The work in general physics begins with the study of kinematics, statics, kinetics, and the mechanics of fluids. The term's work concludes with the study of heat, including an introduction to thermodynamics. Particular attention is paid to harmonic mo-

tion as the basis for the study of such subjects as sound, light, and alternating currents of electricity.

Prerequisites: To be preceded by or accompanied by Mathematics 9a, 11a, and 11b.

Required in I., II., III., and IV.

Sophomore year, second semester, four hours per week. Credit four hours.

Text: Duff, *A Text-Book of Physics.*

2b. GENERAL PHYSICS. *Laboratory.* (McRae, Hollister)

The laboratory is quantitative, and aims, as far as possible, to instruct the student in the methods of physical measurement and the derivation of relations between the quantities measured. Emphasis is laid upon the derivation of physical laws rather than the verification of them.

Prerequisite: Mathematics 7b.

Required in I., II., III., and IV.

Sophomore year, second semester, three hours per week. Credit one and one-half hours.

3a. GENERAL PHYSICS. *Lectures.* (McRae)

This is a continuation of course 1b and includes the study of electricity and magnetism, sound and light. Particular stress is laid upon electrical potential, resistance, and impedance; and upon the reflection, refraction, and interferences of waves. Lectures, illustrated by experiments, and recitations.

Prerequisites: To be preceded by or accompanied by Mathematics 9a and 11a.

Required in I., II., III., and IV.

Junior year, first semester, four hours per week. Credit four hours.

Text: Duff, *A Text-Book of Physics.*

4a. GENERAL PHYSICS. *Laboratory.* (McRae, Hollister)

The work in the laboratory deals with the subjects studied in Physics 3a and the method is the same as that outlined in Physics 2b.

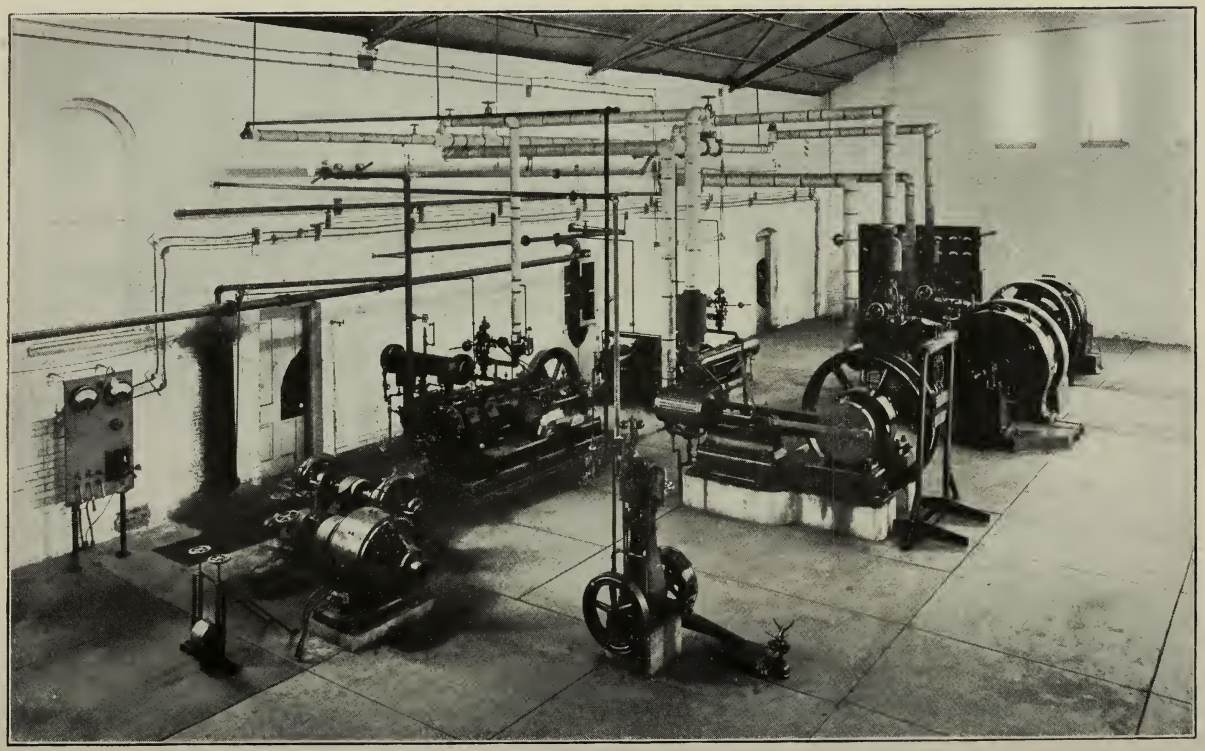
Prerequisite: To be accompanied by Physics 3a.

Required in I., II., III., and IV.

Junior year, first semester, six hours per week. Credit three hours.

5a. THERMODYNAMICS. *Lectures.* (Buerstatte)

A short course in theoretical thermodynamics is followed by a study of boilers, furnaces, and heat engines, standard types of safety and tubular boilers, chimney and mechanical draft, pumps and heaters. Steam, gas, and gasoline engines are also studied.



STEAM LABORATORY

Prerequisites: Mathematics 9a and 11a, and Physics 1b.

Required in I., II., and III.

Junior year, first semester, three hours per week. Credit three hours.

Texts: Cardulo, *Heat Engines.*
Marks and Davis, *Steam Tables.*

6a. STEAM LABORATORY. (McRae, Buerstatte, and Hollister)

Practice is had in operating and indicating steam and gas engines, measuring chimney draft, combustion products, moisture in steam, furnace temperatures, and the calorific value of fuels.

Prerequisite: To accompany Physics 5a.

Required in I., II., and III.

Junior year, first semester, three hours per week. Credit one and one-half hours.

7a, 7b. ELECTRICAL MACHINERY. *Lectures.* (McRae)

This course discusses the magnetic circuit of dynamos and motors, methods of testings and connections for operation of direct current dynamos and motors, of single and polyphase alternating current generators, of induction and synchronous motors, of stationary transformers and rotary converters, and the effects of frequency, resistance, inductance and capacity upon the impedance of alternating current circuits. During the latter part of the course, the design of electrical transmission lines is studied, accompanied by the analytical and graphical solution of practical problems.

Prerequisites: Physics 1b and 3a.

Required in III.

Senior year, first and second semesters, three hours per week. Credit six hours.

Texts: Sheldon and Hausmann, *Dynamo Electrical Machinery.*
Sheldon, Mason, and Hausmann, *Alternating Current Machines.*
Pender, *Principles of Electrical Engineering.*

8a, 8b. DYNAMO LABORATORY. (McRae, Hollister)

This course accompanies course 7a, 7b and consists of calibration of instruments, measurements of ohmic and reactive resistances, insulation resistance and dielectric strength, regulation and efficiency tests of dynamos, motors, transformers, and converters.

Prerequisites: Physics 1b and 3a.

Required in III.

Senior year, first and second semester, three hours per week. Credit three hours.

9a, 9b. ELECTRICITY AND MAGNETISM. (McRae)

This course is designed as an introduction to the study of electricity and magnetism.

Prerequisite: Mathematics 3a.

Elective, first semester, lectures and recitations, five hours per week. Credit five hours.

Second semester, three recitations and one laboratory period per week. Credit four hours.

Text: Timbie, *Elements of Electricity.*

11b. THEORY OF ELECTRICITY AND MAGNETISM. (McRae)

A mathematical treatment of the subject for graduates and undergraduates.

Prerequisite: Physics 3a.

Elective, first semester, three hours per week. Credit three hours.

13a. ALTERNATING CURRENTS. (McRae)

A continuation of Physics 7b and includes a rigorous analytical treatment of the subject as well as a study of the various practical applications in mining and metallurgy.

Prerequisites: Physics 7b and 8b.

Elective, first semester, three hours per week. Credit three hours.

15b. INTERNAL COMBUSTION ENGINES. (McRae)

This course includes the theory of internal combustion engines, as well as their practical application in mining operations and in metallurgical industries.

Prerequisites: Physics 5a and 6a.

Graduate course, second semester, three hours per week. Credit three hours.

16a. POWER PLANT TESTS. *Laboratory.* (McRae, Buerstatte)

This course is a continuation of Physics 6a and consists of tests on power plants and conferences on mining power plants.

Prerequisite: Physics 6a.

Senior year, first semester, three hours per week. Credit one and one-half hours.

17b. MINE POWER PLANTS. *Lectures.* (Buerstatte)

This course comprises a study of the types of engines, boilers, hoists, and machinery used in mine power plants together with their lay out and operation.

Prerequisites: Physics 5a, 6a, 7a, and 8a.

Senior year, second semester, two hours per week. Credit two hours.

Text: Gebhardt, *Steam Power Plant Engineering.*

SHOP PRACTICE AND DRAWING.

Assistant Professor Bowen, Mr. Buerstatte, Mr Johnson,
Mr. Crutcher, Mr. Gammeter.

Equipment.

The shops are thoroughly equipped with machinery and benches adapted to instruction. The wood bench work room contains twenty double benches with separate sets of hand tools. The lathe room is equipped with twenty Fay & Egan 12-in. swing college wood lathes and iron shears. The other machines in the lathe room include a Fay & Egan 27-in. planer, a Fay & Egan band saw with 30-in. wheels, an Oliver universal saw-table, two Oliver wood trimmers, a mortise machine, jig saw, grindstone, and other necessary tools.

For instruction in forge work there are twenty-four Buffalo Forge Company down-draft forges, power hammer, drill press, power shears, and grinder.

The metal-working room contains:

One 20-in. by 8-ft. Reed Lathe.
One 12-in. by 6-ft. Reed Lathe.
One 14-in. by 6-ft. Hendey Lathe.
One 14-in. by 6-ft. American Lathe.
One No. 2A Brown & Sharpe Universal Milling Machine.
One Hendey 15-in. Pillar Shaper.
One Dwight Sensitive Drill.
One Barnes 22-in. Swing Upright Drill Press.
One 24-in. Morse Double Emery Grinder.
One 24-in. by 24-in. by 6-ft. Chandler Planer.
Two Greenard Arbor Presses, No. 3½ and No. 1.
One No. 1 Burr Cold Saw.
One 3-fire Chicago Flexible Shaft Gas Furnace.

All of the above mentioned iron-working machinery is of latest design and driven by individual motors. The benches in the lathe room have hardwood tops mounted on standard Brown & Sharpe bench legs. Twenty-four machinist vises, twelve of which have the swivel base and jaw, equip the shop for bench work.

The drawing rooms are equipped with double drawing tables and will accommodate two hundred and forty students working in two sections.

Courses.

1a. DESCRIPTIVE GEOMETRY. *Lectures and Problems.*
(Buerstatte)

The usual text-book work is reinforced with daily blackboard exercises in presenting the projections of familiar objects, intersections of plane and curved surfaces, sections, developments, and shades and shadows. The afternoons in the drawing room are spent in solving in neat form more elaborate exercises.

Prerequisites: Entrance requirements.

Required in I., II., III., and IV.

Freshman year, first semester, three hours per week. Credit three hours.

2a. MECHANICAL DRAWING. *Laboratory.*
(Buerstatte, Gammeter)

The student is first given practice in geometrical construction until he is familiar with the nature, care and use of drafting instruments. Then, after carefully studying the principles of orthographic projection, intersection, and development, he is thoroughly drilled in free-hand lettering. The course is completed with one term of machine drawing. In this the student is required to make sketches, detail and assembly drawings of machines, and is taught the principles of elementary machine design.

Prerequisites: Entrance requirements.

Required in I., II., III., and IV.

Freshman year, first semester, six hours per week. Credit three hours.

Text: *French, Engineering Drawing.*

2b. MECHANICAL DRAWING. *Laboratory.*
(Buerstatte, Gammeter)

A continuation of Shop Practice and Drawing 2a.

Prerequisites: Shop Practice and Drawing 1a and 2a.

Required in I., II., III., and IV.

Freshman year, second semester, six hours per week. Credit three hours.

4a. MACHINE DRAWING. *Laboratory.* (Buerstatte)

This course is a continuation of the work in mechanical drawing of the Freshman year. It includes exercises covering gearing, power transmission, mechanism, and the simpler machines used in mining, ore dressing, and metallurgy.

Prerequisite: Shop Practice and Drawing 2b.

Elective.

First semester, six hours per week. Credit three hours.

MECHANICAL BUILDING

4b. MACHINE DRAWING. *Laboratory.* (Buerstatte)

This course is a continuation of Shop Practice and Drawing 4a.

Prerequisite: Shop Practice and Drawing 4a.

Elective.

Sophomore year, second semester, six hours per week. Credit three hours.

12a. WOOD WORK. *Laboratory.* (Bowen, Johnson)

The work in the wood shop aims to train the student in the use of wood-working tools and machinery and to familiarize him with the properties of the common woods. All work is done from drawings.

Prerequisites: Entrance requirements.

Required in I., II., III., and IV.

Freshman year, first semester, six hours per week. Credit three hours.

14b. FORGE WORK. *Laboratory.* (Bowen)

This course begins with simple exercises in drawing, upsetting, bending, twisting, punching, and welding. The work gradually becomes more difficult, such as making eye-bolts, chains, and tongs. Tool making is then begun by making screw-drivers, hammers, chisels, and a complete set of lathe tools to be used later in the machine shop. This work is fully illustrated by drawings and lectures on the subject, covering the properties of the different grades of iron and steel. The instructors make the student familiar with the best grade of steel to be used for any required purpose, and the correct shape and temper necessary for the best work in cutting iron, steel, brass, and stone. The final and most important part of this work is the testing of rock-drills of different makes, care being taken to preserve the result of the tests on different grades of steel used.

Prerequisite: Shop Practice and Drawing 12a.

Required in I., II., III., and IV.

Freshman year, second semester, six hours per week. Credit three hours.

16a. FORGE WORK. *Laboratory.* (Bowen)

This course is a continuation of Shop Practice and Drawing 14b.

Prerequisite: Shop Practice and Drawing 14b.

Elective.

Junior year, first semester, six hours per week for eight weeks. Credit one and one-half hours.

18a. MACHINE SHOP. *Laboratory.* (Bowen)

This course begins with chipping to a line, filing to a dimension, and scraping to a surface plate. Machine operation is then begun; the principles and uses of the drill-press, lathe, planer, shaper, and milling machines are taught by lectures followed by practical work at each machine. After a reasonable time, skill is attained in operating the various machines through a course of graded exercises. In this work use is made of the vernier, micrometer, thread-micrometer, and gear tooth caliper. The degree of accuracy thus acquired enables the student to use eye and hand in unison, and is a lasting benefit in teaching exactness in statement and measurement.

Prerequisite: Shop Practice and Drawing 16a.

Elective.

Junior year, first semester, six hours per week for nine weeks. Credit one and one-half hours.

PHYSICAL TRAINING.

Mr. McCleary.

Jackling Athletic Field and the temporary gymnasium in Mechanical Hall offer opportunities for the physical training of students.

The field, constructed by virtue of a gift of Mr. D. C. Jackling, '92, was first used in 1909 and provides a football gridiron, a baseball diamond, and quarter-mile running track for class and intercollegiate games and events. A number of tennis courts have been laid out and are maintained in good order. On the field there is a building providing shower-baths and dressing-rooms for the various athletic teams.

The gymnasium in Mechanical Hall provides room for indoor exercises and games during the winter months.

The Forty-Seventh General Assembly made an appropriation of seventy thousand dollars for a fire-proof gymnasium. This will contain the usual gymnasium equipment and will provide for as many indoor sports as possible. It will contain a swimming-pool, showers, lockers, etc.

All branches of athletics are under the supervision of the Athletic Director and are managed by the Board of Control, which consists of a member of the Faculty, an undergraduate, and the Director of Athletics.

EXCURSIONS.

The State of Missouri occupies an important place in the mining industry, leading in the production of lead, zinc, cobalt, nickel, barite, and tripoli. Many opportunities are offered students at the School of Mines and Metallurgy for keeping closely in touch with the mining industry of Missouri and adjoining States. There have been many important developments during the last few years in methods of mining, dressing, and smelting lead and zinc ores. The lead district of Southeast Missouri and the zinc district of Southwest Missouri offer numerous examples of up-to-date practice in mining and metallurgical engineering. The aggregate tonnage capacity of the concentrating plants of Missouri is greater than that of any other state of the Union. The importance of modern methods of ore dressing is everywhere recognized and the facilities offered by the School of Mines for investigation in ore dressing, together with the practice in concentrating plants which are visited, places the School of Mines and Metallurgy in the foremost rank in this important branch of mine engineering.

Required.

A. At the close of the Sophomore year a two-weeks' trip for mine surveying. This work is usually done in the coal mines adjacent to St. Louis.

Required of all candidates for the degree of Bachelor of Science in Mine Engineering.

B. At the opening of the Junior year, one week's work in topographic surveying. This work is done in the vicinity of Rolla.

Required of all candidates for the degree of Bachelor of Science in Mine Engineering.

C. A three weeks' trip to Colorado and Utah at the close of the Junior year for the study of mining, metallurgy, ore dressing, and geology.

Required of all candidates for degrees in Mining Engineering or in Metallurgy.

D. A three weeks' trip to various points in Missouri during the second semester of the Senior year. The points usually included in this trip are St. Louis, Herculaneum, Crystal City, the Flat River District, Iron Mountain, and the Joplin District.

Required of all candidates for degrees in Mining Engineering or in Metallurgy.

JACKLING FIELD

During the summer the Junior class makes a trip to Colorado and Utah, visiting Denver, Idaho Springs, Central City, Georgetown, Silver Plume, Montezuma, Breckenridge, Leadville, Colorado Springs, Cripple Creek, Victor, and Pueblo in Colorado, and Salt Lake City, Garfield, and Bingham in Utah. Special attention is given to mining practice in the Clear Creek District, the Cripple Creek District, and Leadville and vicinity. Amalgamation is studied in the Clear Creek District; cyanidation at Colorado Springs and Victor; smelting of gold, silver, copper, and lead ores at Leadville and Pueblo; iron and steel metallurgy at Pueblo; treatment of zinc ores at Leadville.

Special attention is paid on these trips to general engineering problems, plant design, economy of operation, and organization.

During the Senior year a trip is made to the metallurgical plants in the vicinity of St. Louis. The plant of the St. Louis Blast Furnace Company illustrates blast-furnace practice. Here may be studied the blast-furnace, regenerative stoves, blowing machinery, power plant, and other appliances necessary for the production of pig iron. Open-hearth steel methods and the manufacture of steel castings are studied at the Scullin & Gallagher Works. This plant includes, in addition to the usual type of open-hearth furnace, Bessemer converters, cupolas, and gas-producers.

The metallurgy of zinc is studied at the Edgar Zinc Works at Carondelet, where the roasting of blende and distillation methods may be seen. The Federal Smelter, at Alton, is visited for the study of lead smelting. At this plant the lead blast-furnace, the Huntington-Heberlin roasting system, and the Scotch ore-hearths are carefully inspected. This plant also includes an extensive bag house. The manufacture of white-lead paint and of lead pipe is seen at the National Lead Works. A further study of lead smelting is made at Herculaneum, where blast-furnaces are served by Savelsberg pot roasters. At the various plants enumerated, particular attention is paid to the construction of furnaces, the operation of the plant, and the general organization and design.

The manufacture of refractory materials is carefully followed from the mine to the finished product at the plant of the Laclede-Christy Company. This plant is one of the largest clay manufacturing works in the world, and a metallurgist here has a splendid opportunity to investigate refractory products and materials used in the construction of furnaces, stacks, retorts, and crucibles.

The class visits Southeast Missouri to study the geology, methods of mining, and the milling of great disseminated lead deposits. The geological work of this trip is especially valuable because of the variety of work introduced. The class has an opportunity to study several varieties of pre-Cambrian rocks of igneous and other origin. Differentiation in magma and intrusions can be seen. The pre-Cambrian topography is discernible in relation to the contact

plane between the pre-Cambrian and the Cambrian. Evidence of superimposed drainage is offered. Iron ores of Shepard Mountain, Pilot Knob, and Iron Mountain give interesting study in the distribution and origin of ores. The general relation of the lead ores of the Paleozoic is also studied. The weathering of various kinds of rock in conjunction with jointing and stratification is well illustrated.

The concentrating plants of Southeast Missouri are large and modern, containing crushers, rolls, elevating machinery, Wilfley tables, Frue vanners, jigs, and sundry other machines. The mining plants are thoroughly modern and include steam and electric hoists, modern steel head-frames, compressed air and electric haulage, extensive pumping plants, and numerous diamond-drill prospecting equipments.

In Southwest Missouri the geology, mining, and milling of the shallow deposits as well as of "sheet" ground are studied by the Seniors. Opportunity is given to inspect and study the various types of equipment and methods as adapted to shallow and deeper mining. Many new concentrating plants have been erected and are strictly modern in design and equipment. The application of electrical power to mining and milling is well illustrated in this district. Short trips are made to neighboring camps in Southeastern Kansas.

GENERAL INFORMATION.

STUDENT ORGANIZATIONS.

The following chapters of college fraternities exist at the School: Gamma Chi of Sigma Nu, Beta Alpha of Kappa Alpha, Beta Chi of Kappa Sigma, Alpha Kappa of Pi Kappa Alpha, and Missouri Beta of Tau Beta Pi.

The Young Men's Christian Association was organized in the College several years ago, and is growing rapidly. It stands for the best there is in college life and brings together those who believe that college men should develop well-rounded characters, physical, mental, and spiritual. During the opening days of the College, trains are met by Association members, who place themselves at the service of the new men, helping them to secure rooms and board and to matriculate. The Association occupies quarters on the second floor of Norwood Hall, where all students are welcomed and regular meetings are held.

Students of the School of Mines maintain a Mandolin Club and an Orchestra.

A student annual, called "The Rollamo," is published by the student body. The purpose of this volume is to record the student activities and to present a review of college life at Rolla.

Student Council.

In order to promote various student enterprises and activities and to maintain a spirit of mutual confidence in the student body and the faculty, there exists in the School of Mines a "Student Council," composed of representatives from the four classes. A committee of the faculty meets with the "Student Council" at all regular meetings and acts in an advisory capacity.

The representatives of the classes for 1912-1913 are:

Senior—R. G. Knickerbocker, J. Hopkins, J. C. Ingram, J. W. Greene.

Junior—S. R. Hatch, L. Lodwick, E. R. Needles.

Sophomore—K. G. Schwegler, J. R. Maher.

Freshman—R. L. Mountjoy.

The members of the Faculty Advisory Committee for 1912-1913 are:

Professor D. Copeland, Chairman.

Dr. A. L. McRae.

Dr. G. H. Cox.
Professor C. R. Forbes.
Mr. E. H. McCleary.

ATHLETICS.

The School encourages rational athletics and has provided an instructor in physical training who has entire supervision of the physical training of students and of all intercollegiate sports. Occasional privileges are granted to athletic teams, but prolonged absences from work are not permitted.

The Jackling Field provides for baseball, football, and other games, and an ample number of tennis courts have been laid out and are maintained in good order. Suitable dressing-rooms and shower-baths are provided in a temporary building on the athletic field. The Forty-Seventh Assembly appropriated Seventy Thousand Dollars for a fire-proof gymnasium. This will be thoroughly equipped and will contain a swimming-pool, a running-track, and various other features. Suitable gymnasium apparatus is supplied and indoor games can be carried on during the winter months. A general athletic association exists among the students.

School of Mines Athletic Association.

The purpose of the association is to unite the efforts of the School of Mines in athletic sports. The officers of the association, together with the Faculty Athletic Committee, have the management of the various athletic teams and supervise all intercollegiate athletic contests. The association maintains football, baseball, basketball, and track teams and encourages other games and sports.

All students are eligible to membership in the Athletic Association upon payment of an annual athletic fee of $10.00.

THE MISSOURI MINING ASSOCIATION.

The objects of the Mining Association are: To advance the knowledge of mining among its members; to promote good fellowship among the students and alumni of the School of Mines and others interested in mining, and to bring the School of Mines into closer relation with the mining profession at large. The membership consists of alumni and students in the School of Mines who have to their credit eighty-five semester hours.

The officers of the Association are:

President.....L. S. Copelin, 1913.
Vice-President.....E. R. Needles, 1914.
Secretary.....L. J. Boucher, 1914.
Treasurer.....A. F. Truex, 1914.

EXPENSES.

Tuition Fee.

Tuition is free to all students who are residents of Missouri. At a meeting held in October, 1908, the Board of Curators voted that "From and after January 1, 1909, non-residents of Missouri who matriculate in any Department of the University be required to pay a tuition fee of $20.00 per year."

Laboratory Fees.

The fees charged are as follows: An incidental and library fee of $5.00 a year, payable upon entrance; a laboratory fee in general chemistry to cover the cost of gas and supplies, $10.00 a semester; a laboratory fee in qualitative analysis of $10.00 a semester to cover the cost of general supplies and gas; a laboratory fee for quantitative analysis and Senior and Junior chemistry laboratory work, $2.00 a semester; a fee of $2.50 a semester to cover the cost of supplies for shop work; a fee of $2.50 a semester to cover the cost of fuel and supplies in forge work; a fee of $2.50 a semester to cover supplies in machine shop; a fee of $25.00 a semester to cover the cost of supplies and fuel in the assay laboratory; a fee of $5.00 a semester for metallurgy laboratory; a fee of $4.50 a semester for mineralogy laboratory; a fee of $2.50 for diploma; a gymnasium and athletic fee of $5.00 a semester.

Excursion Expenses.

The cost of field excursions will average about $50.00 a year. The total expenses of all trips in the four-year mining curriculum is about $200.00.

Contingent Deposits.

A deposit of $15.00 is required from each student to cover the cost of extra supplies and damage to apparatus. This deposit must be renewed if at any time exhausted, and at the end of the school year whatever sum may remain to the credit of the depositor is returned to him.

Annual Expenses.

The following is an estimate of the heaviest items of the student's expenses. As personal tastes vary widely, no estimate of total expenses is offered:

Room rent, nine months, $5.00 to $10.00 per month, average	$ 65.00
Board, thirty-six weeks, $4.00 per week, average	144.00
Fees, excluding tuition	55.00
Drawing instruments (first year) and books	25.00

FEES IN MINE ENGINEERING CURRICULUM.

FRESHMAN YEAR.

First Semester.

Matriculation	$ 5.00
Contingent Deposit*	15.00
Tuition (free for Missouri students)	10.00
General Chemistry Laboratory	10.00
Shop Work	2.50
Athletic Fee	5.00

Second Semester.

Tuition (free for Missouri students)	10.00
Qualitative Analysis Laboratory	10.00
Forge	2.50
Athletic Fee	5.00

SOPHOMORE YEAR.

First Semester.

Matriculation	5.00
Contingent Deposit*	15.00
Tuition (free for Missouri students)	10.00
Quantitative Analysis Laboratory	2.00
Mineralogy	4.50
Athletic Fee	5.00

Second Semester.

Tuition (free for Missouri students)	10.00
Quantitative Analysis Laboratory	2.00
Mineralogy	4.50
Athletic Fee	5.00

*This is a deposit to cover extra supplies and breakage. An account is kept with each student and at the end of the school year whatever sum may remain to the credit of the depositor is returned to him.

JUNIOR YEAR.

First Semester.

Matriculation	5.00
Contingent Deposit*	15.00
Tuition (free for Missouri students)	10.00
Forge and Machine Shop	2.50
Athletic Fee	5.00

Second Semester.

Tuition (free for Missouri students)	10.00
Assaying	25.00
Athletic Fee	5.00

SENIOR YEAR.

First Semester.

Matriculation	$ 5.00
Contingent Deposit*	15.00
Tuition (free for Missouri students)	10.00
Metallurgy Laboratory	5.00
Athletic Fee	5.00

Second Semester.

Tuition (free for Missouri students)	10.00
Athletic Fee	5.00
Diploma Fee	2.50

*This is a deposit to cover extra supplies and breakage. An account is kept with each student and at the end of the school year whatever sum may remain to the credit of the depositor is returned to him.

JACKLING LOAN FUND.

Loans may be made to students of the School of Mines from the Jackling Loan Fund under the following conditions:

1. The student must have been in attendance at the School of Mines one semester.

2. Written requests for loans must be filed with the Director, to be considered at the following meeting of the Executive Committee.

3. Loans may be made to students who cannot give security provided they present the endorsement of the Director of the School and a responsible party not connected with the school.

4. No loans of more than one hundred dollars may be made to any one student during the calendar year.

5. The student shall give his note for the amount of the loan, which note shall bear interest at the rate of five per cent per annum from the date of the note to one year after his graduation or his leaving the School of Mines, and for one year following at the rate of eight per cent per annum. The note shall then become due.

The purpose of the Jackling Loan Fund is to help worthy students who require financial assistance and who are unable to borrow money from other sources.

THE MINING EXPERIMENT STATION.

Officers of the Station.

ALBERT ROSS HILL, PH. D., LL. D.....*President of the University.*
LEWIS EMANUEL YOUNG, E. M.....*Director, and Mining.*
DURWARD COPELAND, S. B.....*Metallurgy and Ore Dressing.*
VICTOR HUGO GOTTSCHALK, M. S.....*Chemistry.*
GUY HENRY COX, M. A., PH. D.....*Geology and Mineralogy.*
MARTIN HARMON THORNBERRY, B. S....*Station Assistant.*

The Mining Experiment Station was established June 1, 1909.

It is the object of the Station to conduct such original researches or to verify such experiments as relate to the properties and uses of mineral products; to investigate the engineering problems connected with the mineral industry, the economic methods of mining and the preparation of mineral products, the methods of preventing waste of the mineral resources and the methods of preventing accidents in mines, mills, and smelters; to assist in improving the conditions surrounding the labor in mines, mills, and smelters; and such other researches or experiments as bear directly upon the application of mining and metallurgical engineering to the mineral industry of the State of Missouri.

The staff of the Station is carrying on investigations on Missouri lead, zinc, and iron ores and on practical problems of interest to operators of coal and metal mines.

Bulletins published by the station are mailed free of charge to citizens of Missouri.

BUREAU OF GEOLOGY AND MINES.

The Geological Survey of the State of Missouri has its headquarters at Rolla, and occupies the Rolla Building on the school campus.

Board of Managers.

GOVERNOR ELLIOT W. MAJOR, Jefferson City.
President.

HON. PHILIP N. MOORE, St. Louis.
Vice-President.

HON. S. DUFFIELD MITCHELL, Carthage.
Secretary.

HON. J. H. BOVARD, Kansas City.

HON. ELIAS S. GATCH, St. Louis.

Staff of the Geological Survey.

H. A. BUEHLER.
State Geologist.

V. H. HUGHES.
Assistant State Geologist.

F. C. GREENE.
Geologist.

M. ALBERTSON,
Geologist.

E. E. HIRDLER,
Chief Clerk.

GERTRUDE STIMSON,
Stenographer.

Equipment and Investigations.

The Geological Survey has at the present time a library of approximately five thousand volumes and pamphlets on geological and allied subjects, and a museum of seven thousand specimens of clay, coal, barite, lead and zinc ore, iron ore, and other mine and quarry products of Missouri.

The Geological Survey is organized principally to aid in the development of the mineral resources of Missouri. Information concerning these resources is gathered through observations in the field by members of the staff. Geologic and topographic maps are prepared of different parts of the State and the various formations are accurately described in accompanying reports. The relation of the geology to the ore deposits is also worked out and detailed reports published concerning such investigations.

The Department has the following reports available for distribution at the present time:

Preliminary Report.....Vol. XIII.
Geology of Miller County.....Vol. I., 2d series.
Quarrying Industry of Missouri.....Vol. II., 2d series.
Geology of Moniteau County.....Vol. III., 2d series.
Geology of the Granby Area.....Vol. IV., 2d series.
Public Roads.....Vol. V., 2d series.
Lime and Cement Resources of Missouri.....Vol. VI., 2d series.
Geology of Morgan County.....Vol. VII., 2d series.
Geology of Pike County.....Vol. VIII., 2d series.
Geology of the Disseminated Lead Deposits of St. Francois and Washington Counties.....Vol. IX., 2d series.
Iron Ores of Missouri.....Vol. X., 2d series.
Coal Deposits of Missouri.....Vol. XI., 2d series.

DEGREES CONFERRED IN 1912.

COMMENCEMENT EXERCISES MAY 31, 1912.

Engineer of Mines.

Hector George Sylvester Anderson, B. S., 1908.
George Albert Easley, B. S., 1909.
Frank James Flynn.
Victor Harmon Hughes, B. S., 1909.
William McElroy, B. S., 1909.

Metallurgical Engineer.

Reginald Henry Brinton Butler, B. S., 1909.
Harry Adam Grine, B. S., 1904.

Master of Science.

Vachel Harry McNutt, B. S., 1910.

Bachelor of Science in Mine Engineering.

Henry Farnum Adams.
Eugene Harding Broughton.
Cairy C. Conover.
Clifford Leroy Conway.
Arthur Harrison Cronk.
Robert Emmett Dye.
William Henry Elbelt.
Frank James Flynn.
Harry Percy Ford.
Dale Irwin Hayes.
Joseph Stuart Irwin.
James Lawton Keelyn.
John Richardson Kenney.
Duane Montgomery Kline.
Edward Dale Lynton.
Roswell Hare Maveety.
Robert Justice Paulette.
William Porri.
Mark Sheffer.
Homer Kent Sherry.
Thomas Andrew Stroup.
Miller Edward Willmott.
Clark Watson Wright.

Bachelor of Science in Metallurgy.

George Condon.
Norman Lloyd Ohnsorg.
George Sylvester Thomas.

Bachelor of Science in Civil Engineering.

John Hurtgen.
Arch Waugh Naylor.

Bachelor of Science in General Science.

Oscar Nicholas Bribach.
Scott David Callaway.
James Howard Chase.
Paul Ephraim Coaske.
Louie Lincoln Coover.
Alexander Grosberg.
Dwight Deane Harris.
Julian Adolph Hielscher.
Robert Winters Johnson.
Edwin Robinson Morris.
Martin Harmon Thornberry.

STUDENTS OF THE MISSOURI SCHOOL OF MINES AND METALLURGY.

1912-1913.

GRADUATE STUDENTS.

Blake, Frank Orris*.....*Los Angeles, Cal.*
B. S. in. M. E., 1910, School of Mines.

Cook, Paul Richardson*.....*Virginia City, Nev.*
B. S. in. M. E., 1907, School of Mines.

Hirdler, Eva Endurance.....*Rolla, Mo.*
B. S. in G. S., 1911, School of Mines.

Hughes, Victor Harmon.....*Rolla, Mo.*
B. S. in M. E., 1909; E. M., 1912, School of Mines.

Lee, Wallace .....*Rolla, Mo.*
E. M., 1904, Colorado School of Mines.

Minor, Harmon Edwin*.....*Canon City, Colo.*
B. S. in. M. E., 1910, School of Mines.

Pudewa, Arthur Gustav.....*Chicago, Ill.*
B. S. in M. E., 1911, School of Mines.

Riede, Frederick Edward*.....*Austinville, Va.*
B. S. in Metallurgy, 1910, School of Mines.

Smith, Harvey Edson*.....*Paxton, Ind.*
B. S. in. M. E., 1910, School of Mines.

Wolf, Edgar Joseph*.....*Brooklyn, N. Y.*
B. S. in M. E., 1909, School of Mines.

*In Absentia.

SENIORS.

Andrus, Dexter Eli.....*Rockford, Ill.*
Bramson, Charles.....*Rolla, Mo.*
Brooks, L. H.....*Sheridan, Wyo.*
Castillon, Tirso.....*Torreon, Coah., Mex.*
Cepeda, Miguel Leon.....*Rolla, Mo.*
Clayton, Charles Yancey.....*Hannibal, Mo.*
Cody, Frank Wesley.....*St. Joseph, Mo.*
Copelin, Leonard Stephen.....*Great Falls, Mont.*
Ehlers, William, Jr.....*St. Louis, Mo.*
Gleason, Augustus William.....*Chicago, Ill.*
Greene, John Wikoff.....*Liberty, Mo.*
Hellstrand, Gustaf Axel.....*London, England.*
Hollister, Scovill Edward.....*Princeton, Mo.*
Hopkins, James.....*Ramey, Pa.*
Ingram, John Charavelle.....*St. Louis, Mo.*
Katz, Howard M.....*Kissimmee, Fla.*
Knapenberger, William Ralph.....*Brunswick, Mo.*
Knickerbocker, Roy Gould.....*Clymers, Ind.*
Marshall, Holman.....*Rolla, Mo.*
Moore, Phillip Aylesworth.....*St. Louis, Mo.*
Murphy, John Andrew.....*Rolla, Mo.*
Nowlan, Harry Hackett.....*Rolla, Mo.*
Radcliffe, Donald Hewson.....*Rolla, Mo.*
Seward, J. Frederick.....*Hillsboro, Ill.*
Shaw, Harry.....*St. Louis, Mo.*
Sickly, Robert Glenn.....*Rolla, Mo.*
Wagstaff, Richard Alexander.....*Springfield, Mo.*
Webster, John Nixon.....*Creston, Iowa.*
Wilson, Thaddeus Constantine.....*Springfield, Mo.*

JUNIORS.

Blair, John Merrill.....*Carthage, Mo.*
Boucher, Leonidas James.....*Marshalltown, Iowa.*
Collins, Lawrence.....*Rolla, Mo.*
Cowman, Gerard.....*Rolla, Mo.*
Crutcher, Thomas Estus.....*Marshall, Mo.*
Cushwa, Claude Calvin.....*Independence, Mo.*
Downing, Clyde Virgil.....*Kirksville, Mo.*
Finagin, Jr., Joseph Cooper.....*Rolla, Mo.*
Goldsborough, Thaddeus Reamy.....*Washington, D. C.*
Hall, Clyde Willis.....*Moundville, Mo.*
Halsey, Howard Gove.....*Kansas City, Mo.*
Hatch, Sidney Raymond.....*Rolla, Mo.*
Hogoboom, William Coryall.....*Los Angeles, Cal.*
Kayser, Edwin Alexander.....*St. Louis, Mo.*

Kelly, Mervin Joe.....*Lathrop, Mo.*
Lodwick, Llewelyn.....*Ottumwa, Iowa.*
Martin, Elmer Dean.....*Kansas City, Mo.*
Metz, Gilbert Frank.....*St. Louis, Mo.*
Miller, Jr., Julius C.....*Joplin, Mo.*
Moses, Fred Gallaway.....*Kansas City, Mo.*
Needles, Enoch Ray.....*Kansas City, Mo.*
Pierce, William Wallace.....*Rolla, Mo.*
Robson, Thomas .....*Potosi, Bolivia, S. A.*
Simrall, Riley Marsh.....*Liberty, Mo.*
Smith, Clinton DeWitt.....*Austin, Minn.*
Stoliker, Edmond Otis.....*Creston, Iowa.*
Stroup, Jacob Carlton.....*Rolla, Mo.*
Thomas, Thomas Rae.....*St. Louis, Mo.*
Truex, Arthur Fuller.....*Rochester, N. Y.*
Wager, Walter Henry.....*Newtownia, Mo.*
Walton, Roland Ralph.....*Higbee, Mo.*

SOPHOMORES.

Aves, William Leonard.....*Seabrook, Texas.*
Benham, Willard Mills.....*Elvins, Mo.*
Canoll, Leon Horton.....*Rolla, Mo.*
Cole, Joseph Bryant.....*Joplin, Mo.*
Damotte, Edward Victor.....*Rolla, Mo.*
Doyle, John Joseph.....*St. Louis, Mo.*
Elayer, Carl Sigmund.....*East St. Louis, Ill.*
Elliott, William .....*St. James, Mo.*
Erskine, Greene .....*St. Louis, Mo.*
Fernandez, Arturo C.....*Monterrey, N.L., Mex.*
Finley, Delbert Dale.....*Wellington, Kan.*
Galloway, Ralph Arthur.....*Hutchinson, Kan.*
Gammeter, Walter .....*St. Louis, Mo.*
Gildehaus, Paul Emmit.....*St. Louis, Mo.*
Griffin, Roy Watson.....*Cleveland, Ohio.*
Hanni, Frederick Henry.....*Troy, Mo.*
Hayden, Roy Wilber.....*Muncie, Ind.*
Johnson, Frank Lindley.....*St. Louis. Mo.*
Kaplan, Abe L.....*St. Louis, Mo.*
Kline, Harry Daniel.....*Rolla, Mo.*
Leavitt, Joseph Edwin.....*Houston, Mo.*
Lepper, Lewis Edward Weston.....*Marlboro, Mass.*
Lyons, Leo Daniel.....*Springfield, Mo.*
McCague, Thomas Purcell.....*Medicine Lodge, Kan.*
Maher, John Ralph.....*Rolla, Mo.*
O'Neill, Charles Henry.....*Webb City, Mo.*
Ruebel, Ernest H., Jr.....*St. Louis, Mo.*

Schroer, Edward Albrecht.....*Clayton, Mo.*
Schwegler, Karl George.....*Washington, D. C.*
Shotwell, John Warden, Jr.....*Chihuahua, Mex.*
Trent, Albert Leo.....*Johnstown, Pa.*
Wilkins, Ralph .....*Idaho Springs, Colo.*
Wilson, Homer Marvin.....*Del Rio, Texas.*

FRESHMEN.

Adams, Bernard William.....*Hamilton, Mo.*
Allen, John James.....*St. Louis, Mo.*
Arpe, Edward William.....*St. Louis, Mo.*
Baker, Charles Albert.....*Rolla, Mo.*
Beeghly, Wood Davis.....*New York City, N. Y.*
Bennett, Roy Linwood.....*Raton, N. Mex.*
Beyer, Emil L.....*St. Louis, Mo.*
Bland, Clark C.....*Rolla, Mo.*
Bower, Clyde Walter.....*Sedalia, Mo.*
Brown, James William.....*Falls Church, Va.*
Cameron, Robert Duncan.....*East St. Louis, Ill.*
Campbell, Eugene Wallace.....*Carthage, Mo.*
Chamberlain, Carleton Guy.....*St. Louis, Mo.*
Cole, John Thomas.....*Fredericktown, Mo.*
Corey, Greyton Civille.....*Chicago, Ill.*
Craig, Robert .....*Osage City, Kan.*
Danielson, John Ronald.....*Anaconda, Mont.*
Dean, Reginald Scott.....*Rolla, Mo.*
Deutman, Earl George.....*St. Louis, Mo.*
Dowd, James Joseph.....*St. Louis, Mo.*
Dunham, Azmon Thurman.....*Craddock, Mo.*
East, Mervin Glazier.....*Rolla, Mo.*
Elliott, Loren Ferrell.....*Rolla, Mo.*
Fitzpatrick, James Anthony.....*Anaconda, Mont.*
Galbraith, John Gray.....*Waverly Mills, S. C.*
Gale, Albert Charles.....*Rolla, Mo.*
Gannon, Kenrick Irwing.....*St. Louis, Mo.*
Garesche, Rowe Alexander.....*St. Louis, Mo.*
Gold, Charles .....*St. Louis, Mo.*
Hanrahan, James .....*Rolla, Mo.*
Head, James Lawrence.....*Moberly, Mo.*
Heavner, Alonzo .....*Lebanon, Mo.*
Heimberger, Harry Tobias.....*Rolla, Mo.*
Heman, Fred Richard.....*Fort Dodge, Iowa.*
Henley, William Gibbons.....*Carthage, Mo.*
Hoffman, John Stone.....*Leon, Iowa.*
Hoppock, Lewis Needham.....*Lebanon, Mo.*
James, Floyd Dixie.....*St. Louis, Mo.*

Johnson, Gunnard Edmund.....*Great Falls, Mont.*
Jones, Earl Ambrose.....*Rolla, Mo.*
Kamp, William Henry.....*St. Louis, Mo.*
Keeling, Orval .....*Rolla, Mo.*
Klepel, Yaro .....*St. Louis, Mo.*
Krebs, Joseph Jackson.....*Lake Charles, La.*
Lawrence, Nathaniel M.....*St. Louis, Mo.*
Lee, Charles Alfred .....*Rolla, Mo.*
Lee, James Thomas .....*Rolla, Mo.*
McCartney, William Henry.....*Webster Grove, Mo.*
McKinley, Lionel William.....*Fort Dodge, Iowa.*
Mann, Harlan Oliver .....*Aurora, Mo.*
Marquiss, Frank Elsworth.....*Webb City, Mo.*
Marquiss, Louis .....*Webb City, Mo.*
Marsh, Harold .....*Thayer, Mo.*
Martin, Thurman Ephian .....*Lancaster, Mo.*
Miller, Elton Arthur .....*Carbondale, Ill.*
Miller, John Charles .....*St. Louis, Mo.*
Miller, Robert McClain .....*Cairo, Ill.*
Mit, Otto Robert.....*Joplin, Mo.*
Mize, Charles R.....*Independence, Mo.*
Mountjoy, Richard LeRoy.....*Webb City, Mo.*
Muench, Raymond Eugene.....*Union, Mo.*
Neustaedter, Harold Arthur.....*Jersey City, N. J.*
O'Brien, John Francis.....*Rolla, Mo.*
Paar, Henry Adolph.....*Jackson, Mo.*
Patten, Cecil Clemant.....*Webb City, Mo.*
Perry Eugene Sheridan.....*Danville, Ill.*
Reaves, Harry H.....*Kansas City, Mo.*
Remy, Clayton LeRoy.....*Mansfield, Ohio.*
Sailer, Edward Louis.....*Cape Girardeau, Mo.*
Sawade, Charles Francis.....*St. Louis, Mo.*
Scheurer, Leroy Robert.....*Wichita Falls, Texas.*
Schuman, Edwin Kaine .....*Rolla, Mo.*
Schuman, John Morris .....*Rolla, Mo.*
Sides, Harry .....*Webb City, Mo.*
Siegrist, Clifford Joseph.....*Festus, Mo.*
Smith, Virgil X.....*Rolla, Mo.*
Spafford, Roy .....*Moran, Kan.*
Stewart, Milton W.....*Independence, Mo.*
Stromvall, Ernest Malcolm.....*W. Somerville, Mass.*
TenBroek, Baarant .....*St. Louis, Mo.*
Tompkins, Edwin Lee.....*E. Orange, N. J.*
Torp, Charles Albert.....*Higginsville, Mo.*
Triefenbach, George Louis.....*St. Louis, Mo.*
Trowbridge, Henry Anthony.....*Rolla, Mo.*
Turnbull, Louis Alan, Jr.....*St. Louis, Mo.*

Turner, James Deyell.....*Springfield, Mo.*
Tyson, Jenson .....*Rolla, Mo.*
Ude, George Edgar.....*St. Louis, Mo.*
Vogel, Herman .....*St. Louis, Mo.*
Vogele, Allen W.....*Sabetha, Kan.*
Weiberg, Earl .....*Springfield, Ill.*
White, Kenrick .....*Rolla, Mo.*
Wilkerson, Riley D.....*St. Louis, Mo.*
Woolrych, Edmund Hugh.....*St. Louis, Mo.*
Wornall, Richard Bristoe.....*Liberty, Mo.*
Worthington, Williard Thomas.....*Moran, Kan.*

SPECIAL STUDENTS.

Bryant, Edwin A.....*Dixon, Mo.*
Hart, John Sylvester.....*Rolla, Mo.*
Holmes, Cyrus .....*Burbank, Mo.*
Johnson, Joseph Thomas.....*Doniphan, Mo.*
Spencer, Herbert Galen.....*Rolla, Mo.*
Valerius, Michael M.....*Roseburg, Ore.*

ALUMNI.

Adams, Henry Farnum, '12..... *P. O. Box 1331, Clifton, Ariz.*
Cost Department on Construction, New Smelter, Arizona Copper Co.

Albertson, Maurice Merton, '11.....*Rolla, Mo.*
Assistant Geologist, Bureau of Geology and Mines.

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Alexander, Thompson, '01.....*Portland, Ore.*
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Anderson, Perry Barton, '97.....

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Baker, Charles Armstrong, '08.....

Barker, Ralph, '98.....

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Bartlett, Albert Babbitt, '07.....*Cheyenne, Wyo.*
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Bell, Frank Rolla, '03.....*Bartlesville, Okla.*
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Bowles, James Joseph, '10.....*Lake Springs, Mo.*

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Boyer, George Hewitt, '08.....*Racine, Wis.*

Boza, Hector, '11.....*Lima, Peru.*
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Brown, William Ernest, '07.....

Brown, Wilton Rutherford, '78.....

Buckby, DeNard Wilson, '01.....*Wallace, Idaho.*
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Bunten, James, '10.....*Canon City, Colo.*
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Burgher, Mark Bernardi, '06.....*Hannibal, Mo.*

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Chamberlain, Harry Carleton, '05.....*Gila Bend, Ariz.*
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Chamberlain, Santiago, '00.....
Chase, James Howard, '12.....*Logansport, Ind.*
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Clark, George Clough, '99.....
Deceased.
Clark, John Charles, '11.....*Rolla, Mo.*
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Clark, William Newton, '09.....
Clarke, William Danels, '09.....*1911 17th St., Bakersfield, Cal.*
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Clary, John Henry, '05.....*Maryville, Mo.*
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Claypool, William M., '84.....*Needles, Cal.*
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Coaske, Paul Ephraim, '12.....*St. Louis, Mo.*
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Cole, George W., '87.....
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Conover, Cairy C., '12..... ....*Carrollton, Mo.*
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Cook, Paul Richardson, '07.....*Virginia City, Nev.*
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Coppedge, Lindsay L., '78.....
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Deegan, Francis J., '75.....
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Delano, Lewis Alfred, '04.....*Bonne Terre, Mo.*
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Dobbins, Walter, '10.....*Hurley, N. Mex.*
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Don, DeForrest, '09.....*St. Francois, Mo.*
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Dosenbach, Benjamin Harrison, '10.....*Butte, Mont.*
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Dye, Robert Emmett, '12.....*Cobalt, Ontario, Canada.*
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Dyer, T. E., '94.....*Rolla, Mo.*

Eardley, Albert Edwin, '97.....*Carrizo Springs, Tex.*
Contracting and Well Work.

Easley, George Albert, '09.....*La Paz, Bolivia, S. A.*
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Elbelt, William Henry, '12.....*Hurley, N. Mex.*
Chino Copper Co.

Elicano, Victoriano, '09.....*Massinloc, Tambles, P. I.*

Elmore, Carlos Enrique, '11.....*P. O. Box 224, Hazel Green, Wis.*
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Hardware Merchant.

Engelman, Edward William, '11.....*Garfield, Utah.*
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Ericson, John Theodore Emanuel, '07.....*Sligo, Mo.*
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Fach, Charles Albert, '00.....*Security Bldg., St. Louis, Mo.*
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Farrar, Monroe, '11.....*Mattoon, Ill.*
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Fay, Albert Hill, '05.....*Washington, D. C.*
U. S. Bureau of Mines.

Fellows, Aubrey P., '07.....*Collinsville, Ill.*
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Fernandez, Abraham Leonardo, '00,
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Superintendent, Nego. Minera, El Cigararro.

Florreich, Phillip, '95.....
Deceased.

Flynn, Frank James, '12.....*St. Joseph, Mo.*

Flynt, Frank LeRoy, '10.....*110 E. Main St., Maryville, Mo.*
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Ford, Harold Percy, '12.....*Lake Linden, Mich.*
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Forman, John Kavanaugh, '10.....*805 W. Granite St., Butte, Mont.*

Forrester, David Lawton, '11.....*Flat River, Mo.*
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Foster, Leo Joseph, '04.....*Montrose, Colo.*
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Fowler, James Duncan, '08.....*301 Reliance Bldg., Kansas City, Mo.*
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Fraizer, Isaac Peter, '00.....*Elgin, Ariz.*
Prospector.

Fraser, Keith Colt, '10.....*Kellogg, Idaho*
Engineering Corps, Bunker Hill & Sullivan Mining Co.

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Garcia, Germin, '11.....*2 de Marcella No. 16, Mexico, Mexico, D. F.*
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Gardiner, William Alexander, '06.....*El Oro, Mex.*
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Garrett, Leon Ellis, '01.....*Rolla, Mo.*
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Garst, Harvey Oden, '09.....*Trenton, Mo.*
City Engineer, and County Highway Engineer.

Garvens, Oscar E., '75.....*East St. Louis, Ill.*

Gibb, Frank W., '82.....*Little Rock, Ark.*
Gibb and Sanders, Architects.

Gill, John Holt, '74.....
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Greason, John D., '76.....
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Green, Cecil Theodore, '06.....*Rosario, Son., Mex.*
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Gregory, James Albert, '05.....*1418 Practorian Bldg., Dallas, Tex.*
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Grove, Claude Devlin, '94.....

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Hollinger Gold Mining Co.

Ham, Roscoe Conkling, '09.....*Kansas City, Mo.*
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Hand, Horace Alonzo, '06.....

Hanley, Herbert Russell, '01.....*Winthrop, Shasta Co., Cal.*
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Harper, Frank William, '08.....*Fort Lauderdale, Fla.*

Harris, Dwight Dean, '12.....*Care of Renfro Hotel, Collinsville, Ill.*
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Harris, George William, '04.....

Hartzell, Henry, '06.....*Joplin, Mo.*
Mine Superintendent, Granby Mining and Smelting Co.

Hase, Herman Carl, '08.....*Box 662, Globe, Ariz.*
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Superintendent, Burr Mining Co.
Heck, Elmer Cooper, '05.....*Clifton, Ariz.*
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Hendricks, James Otto, '99.....*Seligman, Mo.*
Herdman, George Walker, '94.....
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Holmes, Oliver Wendell, '10.....*Herculaneum, Mo.*
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Johnson, Edward Mackey, '92.....*Springfield, Ill.*
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Johnson, Horace Asahel, '08.....*Millers, Nev.*
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Johnson, Robert Winters, '12.....Carl Junction, Mo.
Vinegar Hill Mining Co.
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Jones, Elston Everett, '08.....
Jones, Fayette Alexander, '92,
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Kenney, John Richardson, '12.....*Box 747, McGill, Nev.*
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Field Sales Manager, Fairbanks, Morse & Co.
Killian, Ralph Daniel, '10.....*Perryville, Mo.*
Engineer, Levee District No. 2, Perry Co., Mo.
King, Charles LeClair, '04.....*Pachuca, Mex.*
Compania de Real del Monte y Pachuca.
Kirkham, John Edward, '95.....*Ames, Iowa.*
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Kline, Duane Montgomery, '12.....*Blair, Nev.*
Pittsburg-Silver Peak Gold Mining Co.
Koeberlin, Frederick Richard, '01.....
Lachmund, Oscar, '86.....*Greenwood, B. C.*
General Manager, British Columbia Copper Co., Ltd.
Laizure, Clyde McKeever, '05.....*Millers, Nev.*
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Lehman, John Ludwig Gustave, '05.....*Kansas City, Mo.*
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Lindau, Sam Paul.....*Ray, Ariz.*
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Lintecum, Charles Lafayette, '05.....
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Macomber, Sumner Cooley, '11.....*Tipton, Cal.*
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Martinez, Justo G., '86.....
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Moore, Stanley Ralston, '05.....*Superior, Mont.*
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Murray, Edwin Phelps, '08.....*c/o C. T. Heydecker, Hailey, Idaho.*

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Naylor, Arch Waugh, '12.....*Elkhart, Ind.*
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Neer, Don Morgan, '08.....*Box 226, Lometa, Tex.*
Rodman on Construction, Gulf, Colorado & Santa Fe R. R.

Nesbitt, William Corsey, '05.....

Neustaedter, Arthur, '84.....*Ocampo Chihuahua, Mex.*
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Norton, Benjamin Newton, '02.....*Douglas, Ariz.*
City Engineer and Building Inspector.

Nye, Alfred Leo, '09.....*Kearney, Neb.*
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Olmsted, George Lewis, '01.....*Herculaneum, Mo.*
Chemist, Doe Run Lead Co.

Owen, John R. D., '85.....
Deceased.
Pack, James A., '77.....*De Lamar, Idaho.*
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